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Cam et al.

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(54) **VASCULAR REMODELING DEVICE**

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
A61F 2/06 (2013.01)
A61F 2/90 (2013.01)
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(52) **U.S. Cl.**
CPC ***A61F 2/90*** (2013.01); ***A61B 17/1214*** (2013.01); ***A61B 17/12118*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC A61B 17/12118; A61B 17/1214; A61B 17/12145; A61B 17/12168; A61B 17/12172; A61F 2/90; A61F 2/95; A61F 2002/823
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,921,484 A 5/1990 Hillstead
5,122,136 A 6/1992 Guglielmi et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1556689 A 12/2004
CN 101415449 A 4/2009
(Continued)

OTHER PUBLICATIONS

Thorell, et al., "Y-configured Dual Intracranial Stent-assisted Coil Embolization for the Treatment of Wide-necked Basilar Tip Aneurysms," Neurosurgery, May 2005, vol. 56, Issue 5, pp. 1035-1040.

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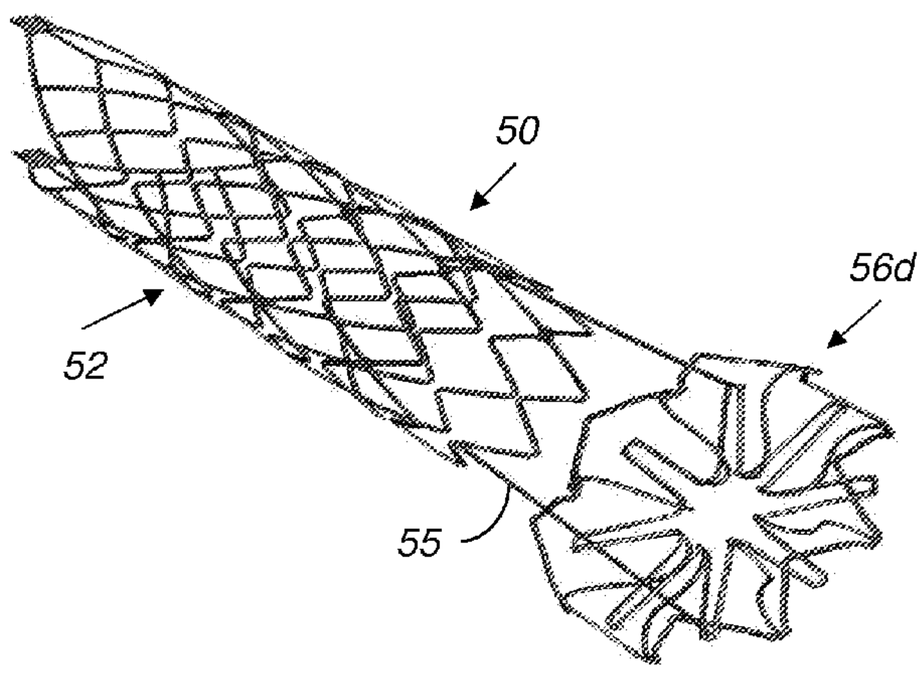
(74) *Attorney, Agent, or Firm* — Mark J. Kertz, Esq.

(57) **ABSTRACT**

Vascular remodeling devices can include a proximal section, an intermediate section, and a distal section. During deployment, the proximal section can expand from a compressed delivery state to an expanded state and anchor the device in an afferent vessel of a bifurcation. The distal section expands from the compressed delivery state to an expanded state that may be substantially planar, approximately semi-spherical, umbrella shaped, or reverse umbrella shaped. The distal section is positioned in a bifurcation junction across the neck of an aneurysm or within an aneurysm. The intermediate section allows perfusion to efferent vessels. Before or after the device is in position, embolic material may be used to treat the aneurysm. The distal section can act as a scaffolding to prevent herniation of the embolic material. The device can be used for clot retrieval with integral distal embolic protection.

16 Claims, 18 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 61/420,275, filed on Dec. 6, 2010, provisional application No. 61/448,506, filed on Mar. 2, 2011.

(51) **Int. Cl.**

A61F 2/95	(2013.01)
A61B 17/12	(2006.01)
A61F 2/82	(2013.01)

(52) **U.S. Cl.**

CPC ***A61B 17/12172*** (2013.01); ***A61F 2/95*** (2013.01); *A61B 17/12145* (2013.01); *A61B 17/12168* (2013.01); *A61F 2002/823* (2013.01); *A61F 2220/005* (2013.01); *A61F 2220/0058* (2013.01); *A61F 2230/0034* (2013.01); *A61F 2230/0054* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,624,461	A	4/1997	Mariant
5,645,558	A	7/1997	Horton
5,690,671	A	11/1997	McGurk et al.
5,725,552	A	3/1998	Kotula et al.
5,728,906	A	3/1998	Eguchi et al.
5,733,294	A	3/1998	Forber et al.
5,879,366	A	3/1999	Shaw et al.
5,911,731	A	6/1999	Pham et al.
5,916,235	A	6/1999	Guglielmi
5,925,060	A	7/1999	Forber
5,928,260	A	7/1999	Chin et al.
5,935,148	A	8/1999	Villar et al.
5,951,599	A	9/1999	McCrory
5,957,948	A	9/1999	Mariant
6,024,756	A	2/2000	Huebsch et al.
6,036,720	A	3/2000	Abrams et al.
6,063,070	A	5/2000	Eder
6,063,104	A	5/2000	Villar et al.
6,086,577	A	7/2000	Ken et al.
6,096,073	A	8/2000	Webster et al.
6,168,615	B1	1/2001	Ken et al.
6,168,622	B1	1/2001	Mazzocchi
6,221,086	B1	4/2001	Forber
6,261,305	B1	7/2001	Marotta et al.
6,306,141	B1	10/2001	Jervis
6,309,367	B1	10/2001	Boock
6,322,576	B1	11/2001	Wallace et al.
6,325,820	B1	12/2001	Khosravi et al.
6,331,184	B1	12/2001	Abrams
6,344,048	B1	2/2002	Chin et al.
6,346,117	B1	2/2002	Greenhalgh
6,350,270	B1	2/2002	Roue
6,375,668	B1	4/2002	Gifford et al.
6,428,558	B1	8/2002	Jones et al.
6,454,780	B1	9/2002	Wallace
6,506,204	B2	1/2003	Mazzocchi
6,517,558	B2	2/2003	Gittings et al.
6,551,303	B1	4/2003	Van Tassel et al.
6,582,463	B1	6/2003	Mowry et al.
6,585,748	B1	7/2003	Jeffree
6,585,756	B1	7/2003	Strecker
6,589,256	B2	7/2003	Forber
6,589,265	B1	7/2003	Palmer et al.
6,605,102	B1	8/2003	Mazzocchi et al.
6,605,111	B2	8/2003	Bose et al.
6,635,068	B1	10/2003	Dubrul et al.
6,635,069	B1	10/2003	Teoh et al.
6,666,883	B1	12/2003	Seguin et al.
6,669,717	B2	12/2003	Marotta et al.
6,669,721	B1	12/2003	Bose et al.
6,676,696	B1	1/2004	Marotta et al.
6,695,876	B1	2/2004	Marotta et al.
6,712,835	B2	3/2004	Mazzocchi et al.
6,730,108	B2	5/2004	Van Tassel et al.
6,746,468	B1	6/2004	Sepetka et al.
6,746,890	B2	6/2004	Gupta et al.
6,780,196	B2	8/2004	Chin et al.
6,797,083	B2	9/2004	Peterson
6,802,851	B2	10/2004	Jones et al.
6,860,893	B2	3/2005	Wallace et al.
6,949,103	B2	9/2005	Mazzocchi et al.
6,953,472	B2	10/2005	Palmer et al.
6,989,019	B2	1/2006	Mazzocchi et al.
6,994,717	B2	2/2006	Konya et al.
7,029,487	B2	4/2006	Greene, Jr. et al.
7,033,375	B2	4/2006	Mazzocchi et al.
7,048,752	B2	5/2006	Mazzocchi et al.
7,128,736	B1	10/2006	Abrams et al.
7,195,636	B2	3/2007	Avellanet et al.
7,229,461	B2	6/2007	Chin et al.
7,232,461	B2	6/2007	Ramer
7,331,980	B2	2/2008	Dubrul et al.
7,367,985	B2	5/2008	Mazzocchi et al.
7,367,986	B2	5/2008	Mazzocchi et al.
7,371,250	B2	5/2008	Mazzocchi et al.
7,404,820	B2	7/2008	Mazzocchi et al.
7,410,482	B2	8/2008	Murphy et al.
7,410,492	B2	8/2008	Mazzocchi et al.
7,413,622	B2	8/2008	Peterson
7,442,200	B2	10/2008	Mazzocchi et al.
7,485,088	B2	2/2009	Murphy et al.
7,556,635	B2	7/2009	Mazzocchi et al.
7,566,338	B2	7/2009	Mazzocchi et al.
7,569,066	B2	8/2009	Gerberding et al.
7,572,273	B2	8/2009	Mazzocchi et al.
7,582,111	B2	9/2009	Krolik et al.
7,621,928	B2	11/2009	Thramann et al.
7,670,355	B2	3/2010	Mazzocchi et al.
7,670,356	B2	3/2010	Mazzocchi et al.
7,678,130	B2	3/2010	Mazzocchi et al.
7,744,652	B2	6/2010	Morsi
7,763,011	B2	7/2010	Ortiz et al.
7,763,065	B2	7/2010	Schmid et al.
7,828,815	B2	11/2010	Mazzocchi et al.
7,828,816	B2	11/2010	Mazzocchi et al.
7,833,259	B2	11/2010	Boatman
7,862,604	B1	1/2011	Marcade et al.
7,887,576	B2	2/2011	Bahler et al.
7,914,567	B2	3/2011	Pavcnik et al.
7,922,732	B2	4/2011	Mazzocchi et al.
7,951,192	B2	5/2011	Yadin et al.
8,388,650	B2	3/2013	Gerberding et al.
8,915,950	B2	12/2014	Cam et al.
2001/0007946	A1	7/2001	Lenker et al.
2003/0028209	A1	2/2003	Teoh et al.
2003/0171739	A1	9/2003	Murphy et al.
2003/0195553	A1	10/2003	Wallace et al.
2004/0111112	A1	6/2004	Hoffmann
2004/0172056	A1	9/2004	Guterman et al.
2004/0186562	A1	9/2004	Cox
2004/0193206	A1	9/2004	Gerberding et al.
2004/0249408	A1	12/2004	Murphy et al.
2005/0033409	A1	2/2005	Burke et al.
2005/0096728	A1	5/2005	Ramer
2006/0052816	A1	3/2006	Bates et al.
2006/0058864	A1	3/2006	Schaeffer et al.
2006/0064151	A1	3/2006	Guterman et al.
2006/0190070	A1	8/2006	Dieck et al.
2006/0264905	A1	11/2006	Eskridge et al.
2006/0264907	A1	11/2006	Eskridge et al.
2007/0016243	A1	1/2007	Ramaiah et al.
2007/0088387	A1	4/2007	Eskridge et al.
2007/0106311	A1	5/2007	Wallace et al.
2007/0173928	A1	7/2007	Morsi
2007/0191884	A1	8/2007	Eskridge et al.
2007/0198075	A1	8/2007	Levy
2007/0203567	A1	8/2007	Levy
2007/0225794	A1	9/2007	Thramann et al.
2007/0225798	A1	9/2007	Gregorich
2007/0265656	A1	11/2007	Amplatz et al.
2007/0270902	A1	11/2007	Slazas et al.
2008/0058856	A1	3/2008	Ramaiah et al.
2008/0109063	A1	5/2008	Hancock et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0114436	A1	5/2008	Dieck et al.
2008/0114439	A1	5/2008	Ramaiah et al.
2008/0125806	A1	5/2008	Mazzocchi et al.
2008/0221600	A1	9/2008	Dieck et al.
2009/0043371	A1	2/2009	Fearnot
2009/0069806	A1	3/2009	De La Mora Levy et al.
2009/0118811	A1	5/2009	Moloney
2009/0143851	A1	6/2009	Paul, Jr.
2009/0264914	A1	10/2009	Riina et al.
2009/0275974	A1	11/2009	Marchand et al.
2009/0287291	A1	11/2009	Becking et al.
2009/0287294	A1	11/2009	Rosqueta et al.
2010/0004726	A1	1/2010	Hancock et al.
2010/0004761	A1	1/2010	Flanders et al.
2010/0023105	A1	1/2010	Levy et al.
2010/0069948	A1	3/2010	Veznedaroglu et al.
2010/0094335	A1	4/2010	Gerberding et al.
2011/0022149	A1	1/2011	Cox et al.
2011/0046719	A1	2/2011	Frid
2011/0160757	A1	6/2011	Ferrera et al.
2011/0184452	A1	7/2011	Huynh et al.
2011/0184453	A1	7/2011	Levy et al.
2011/0245862	A1	10/2011	Dieck et al.
2012/0143237	A1	6/2012	Cam et al.
2012/0143317	A1	6/2012	Cam et al.
2012/0296362	A1	11/2012	Cam et al.
2012/0323160	A1	12/2012	Babkes
2013/0204290	A1	8/2013	Clarke et al.
2013/0304109	A1	11/2013	Abrams et al.
2014/0058420	A1	2/2014	Hannes et al.
2014/0121752	A1	5/2014	Losordo et al.

FOREIGN PATENT DOCUMENTS

CN	102137626	A	7/2011
CN	102361602	A	2/2012
CN	102740799	A	10/2012
CN	102762156	A	10/2012
DE	102008028308	A1	4/2009
EP	1527753	A2	5/2005
WO	WO-97/26939	A1	7/1997
WO	WO-98/50102	A1	11/1998
WO	WO-99/05977	A1	2/1999
WO	WO-01/93782	A1	12/2001
WO	WO-02/00139	A1	1/2002
WO	WO-2005/117718	A1	12/2005
WO	WO-2006/034166	A2	3/2006
WO	WO-2006/119422	A2	11/2006
WO	WO-2007/047851	A2	4/2007
WO	WO-2008/022327	A2	2/2008
WO	WO-2008/151204	A1	12/2008
WO	WO-2009/076515	A1	6/2009
WO	WO-2009/135166	A2	11/2009
WO	WO-2010/028314	A1	3/2010
WO	WO-2010/030991	A1	3/2010
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WO	WO-2012/154782	A1	11/2012

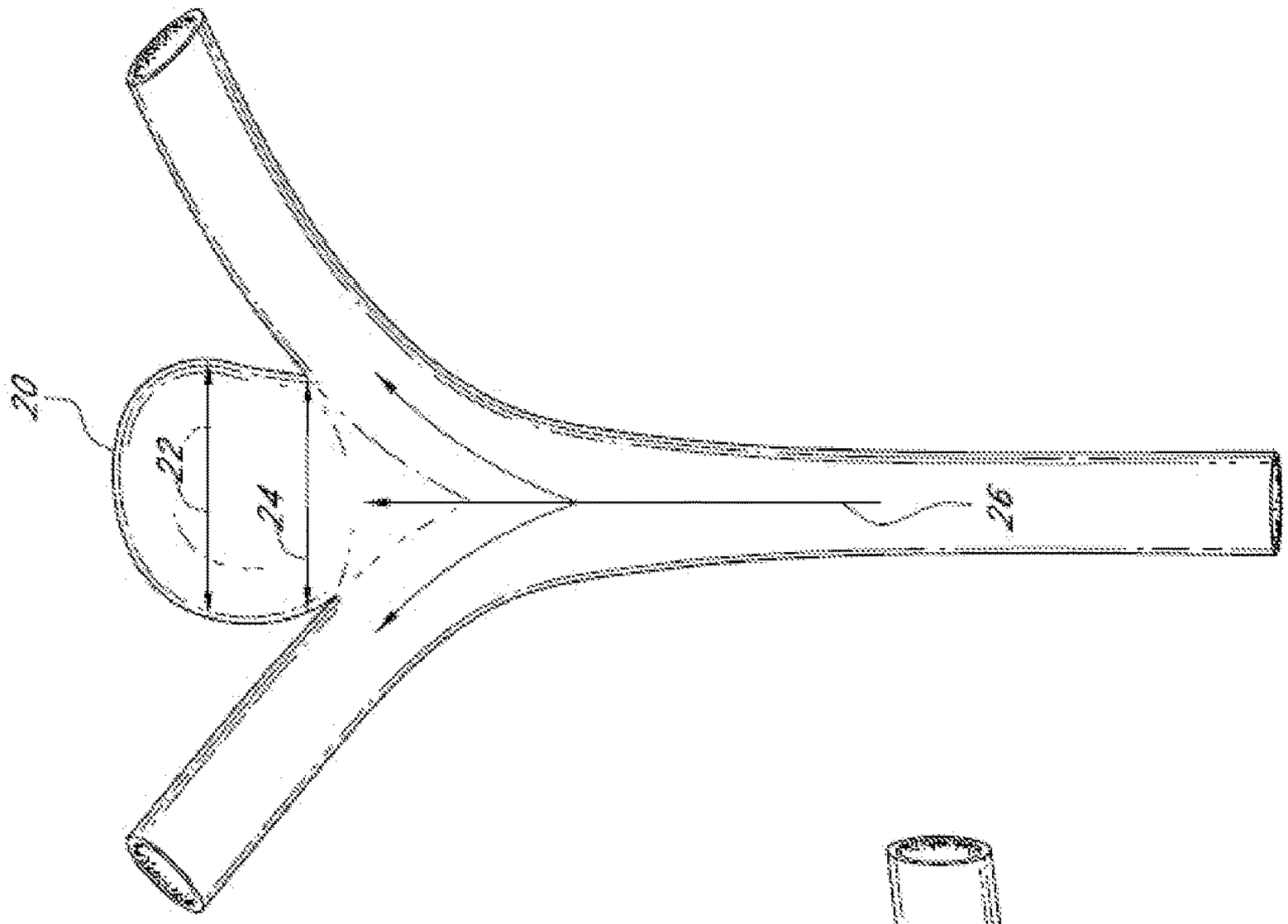

FIG. 2

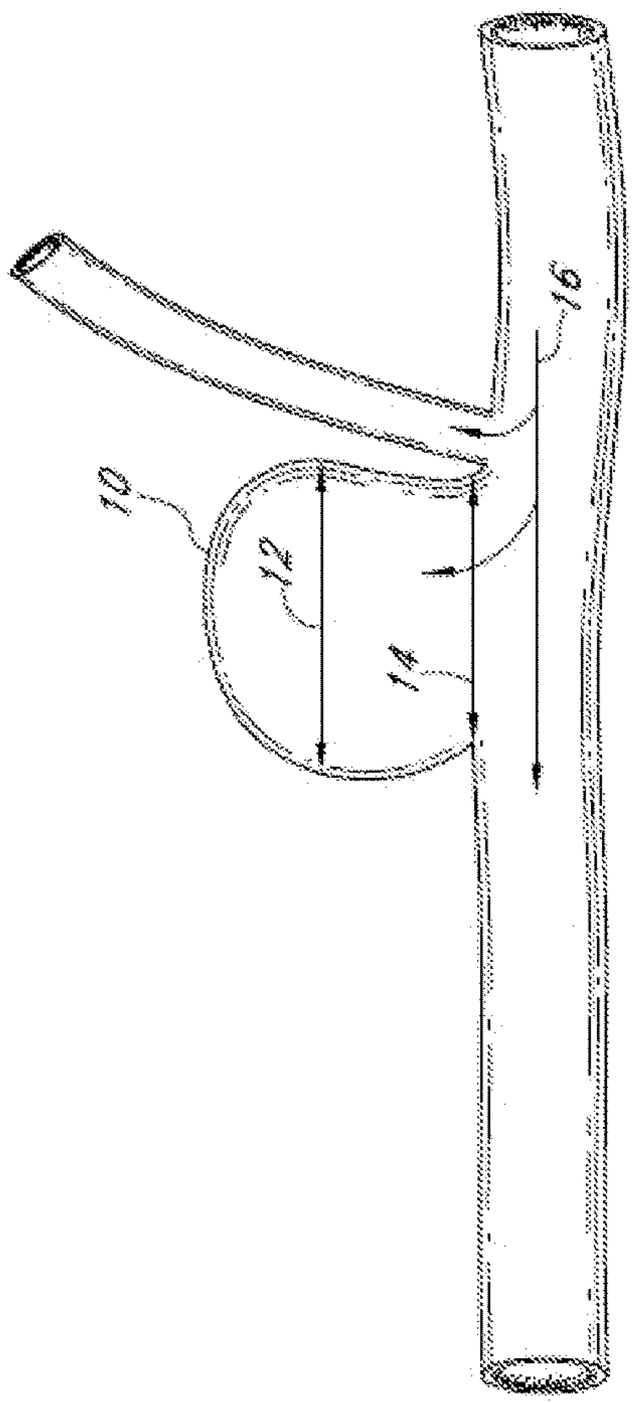

FIG. 1

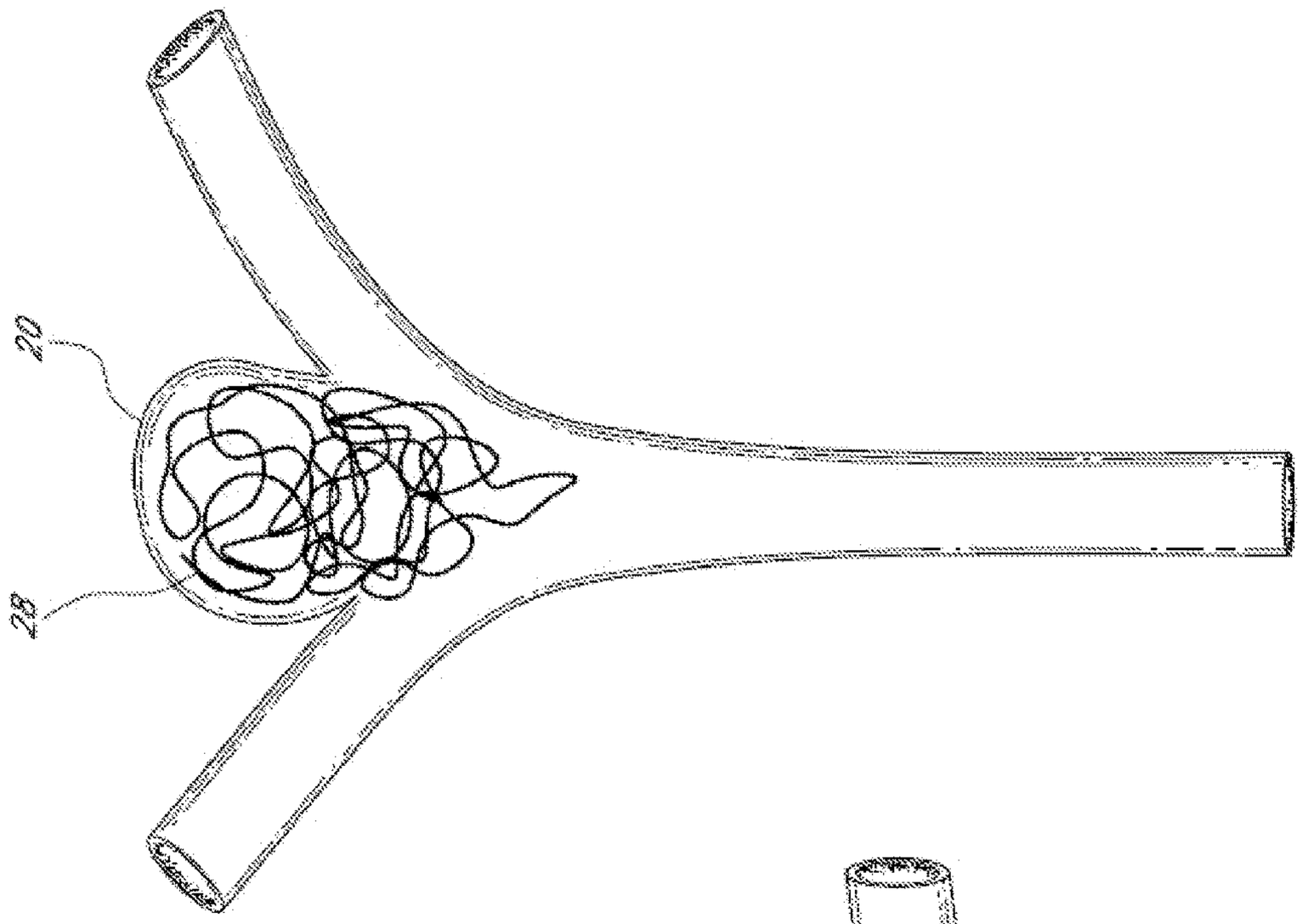

FIG. 3B

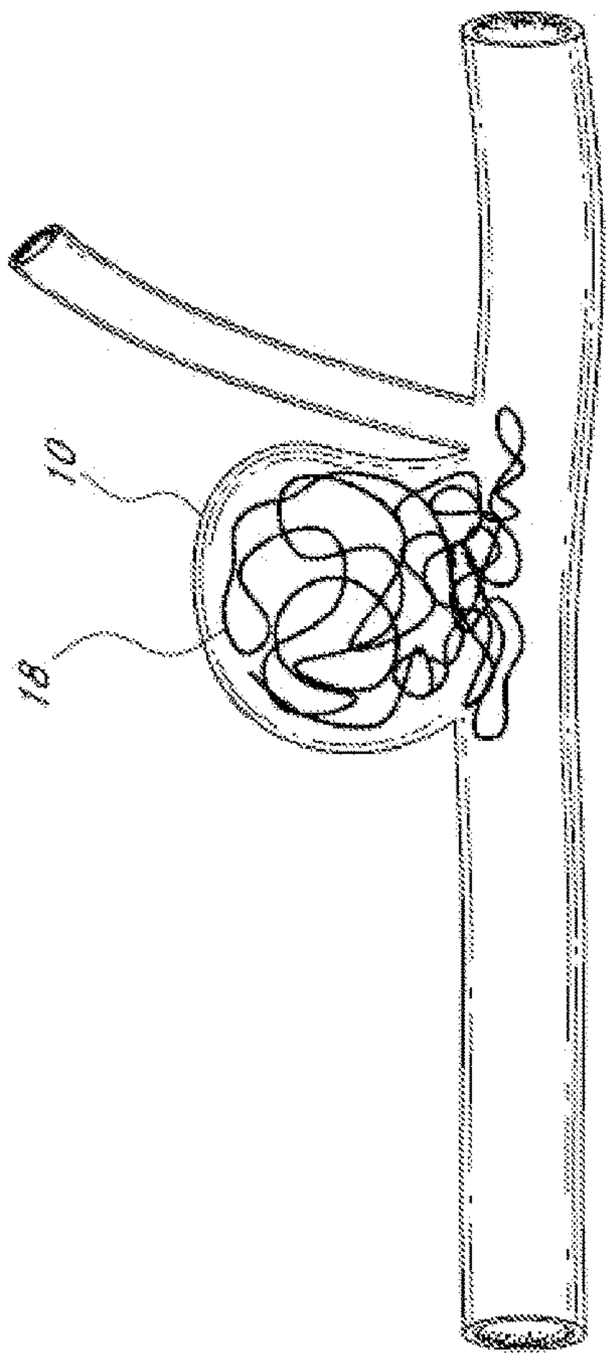

FIG. 3A

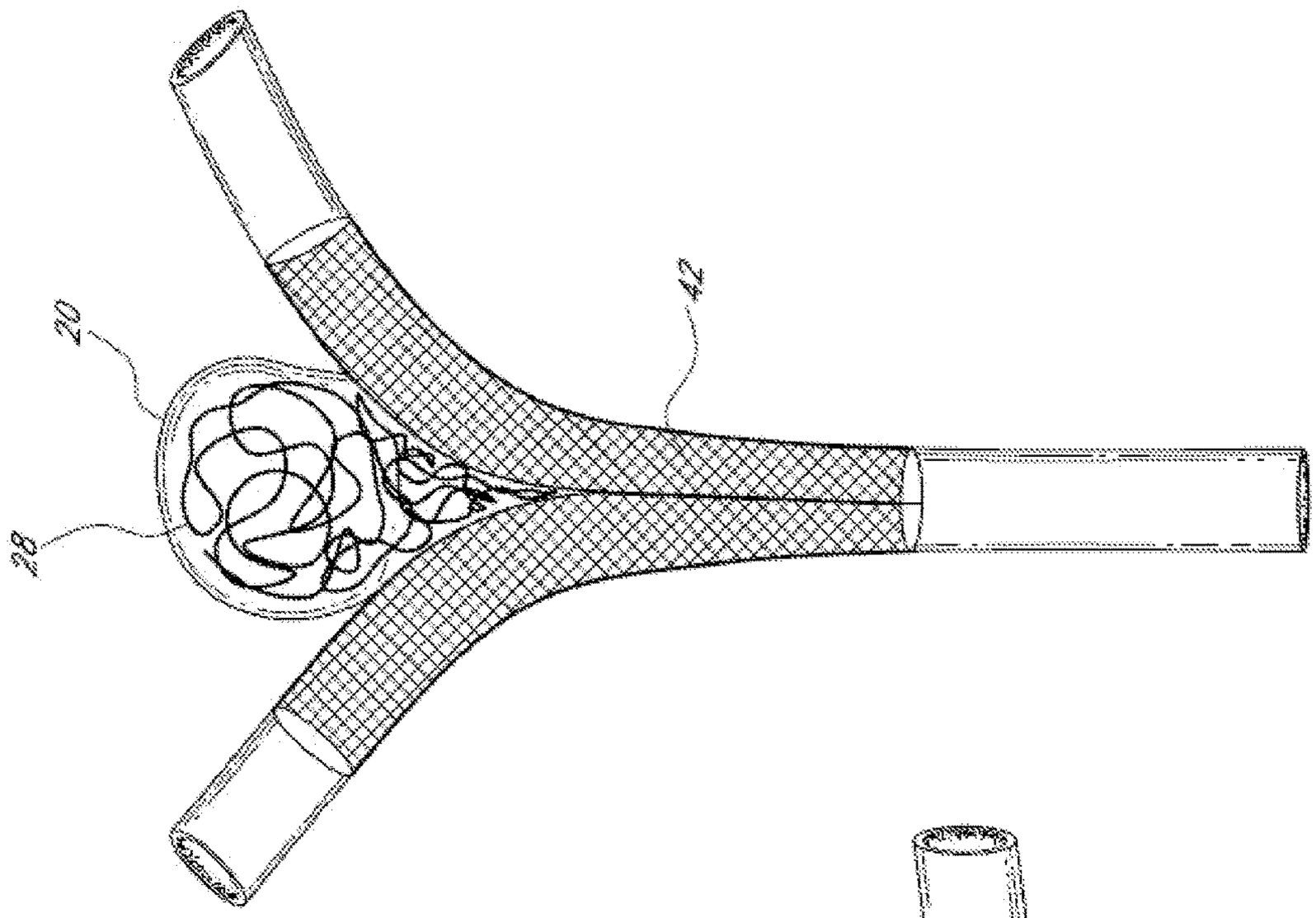

FIG. 4B

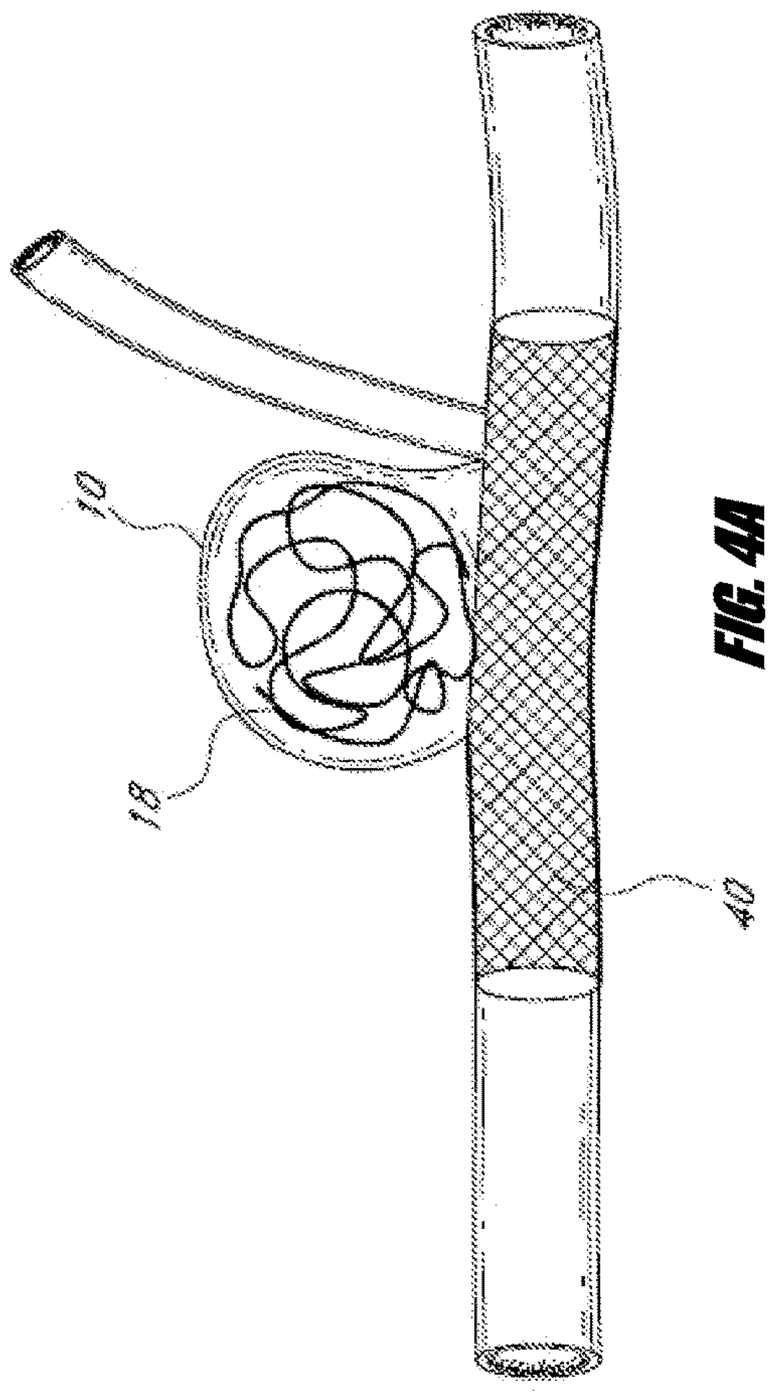

FIG. 4A

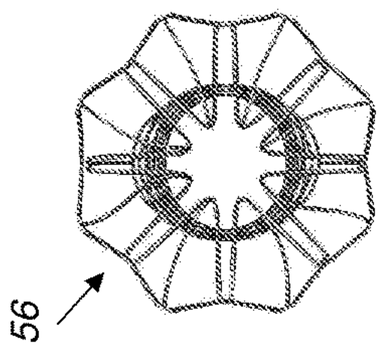

FIG. 5B

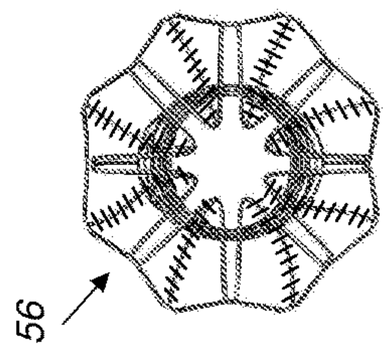

FIG. 5C

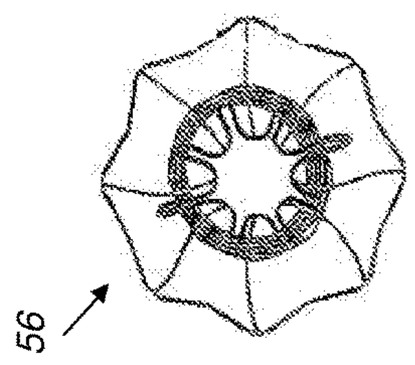

FIG. 5D

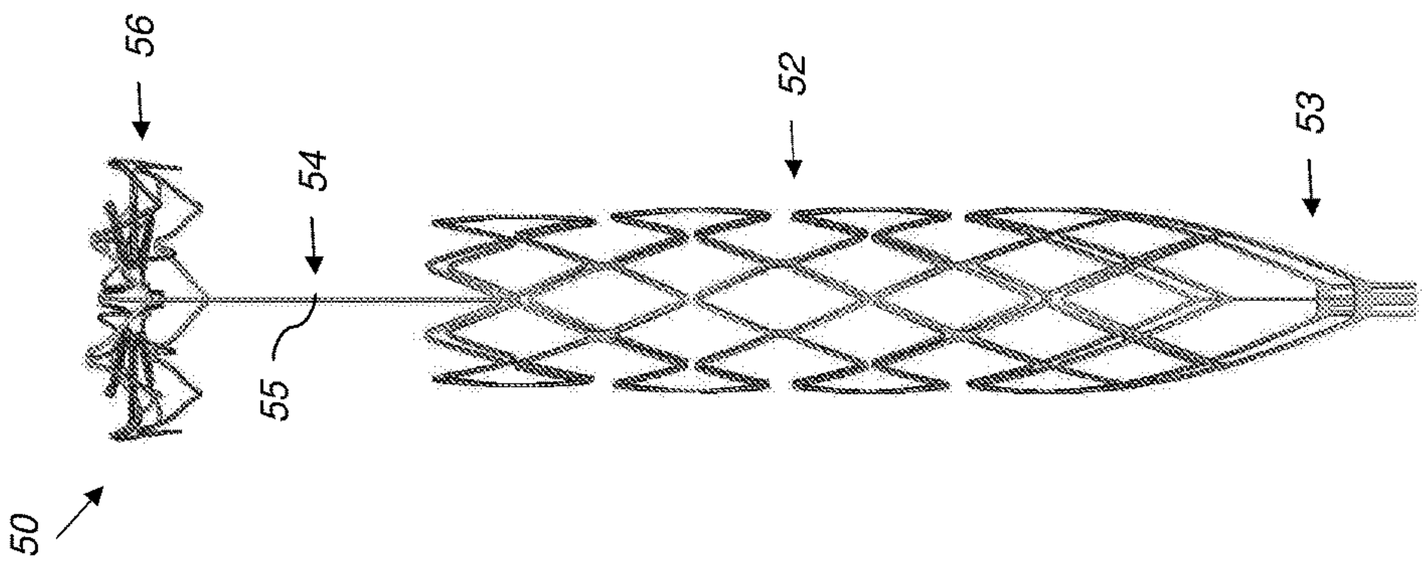

FIG. 5A

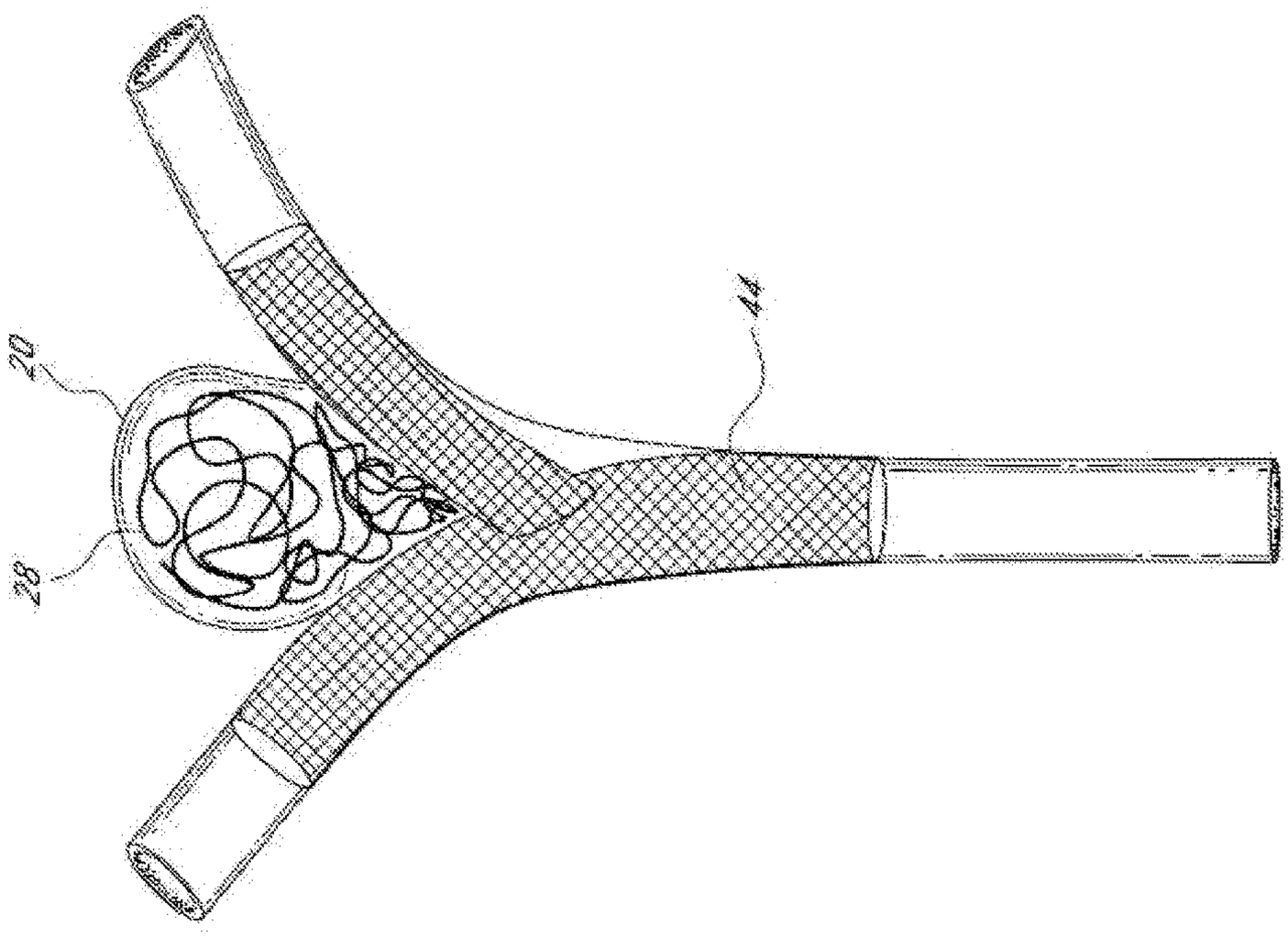

FIG. 4C

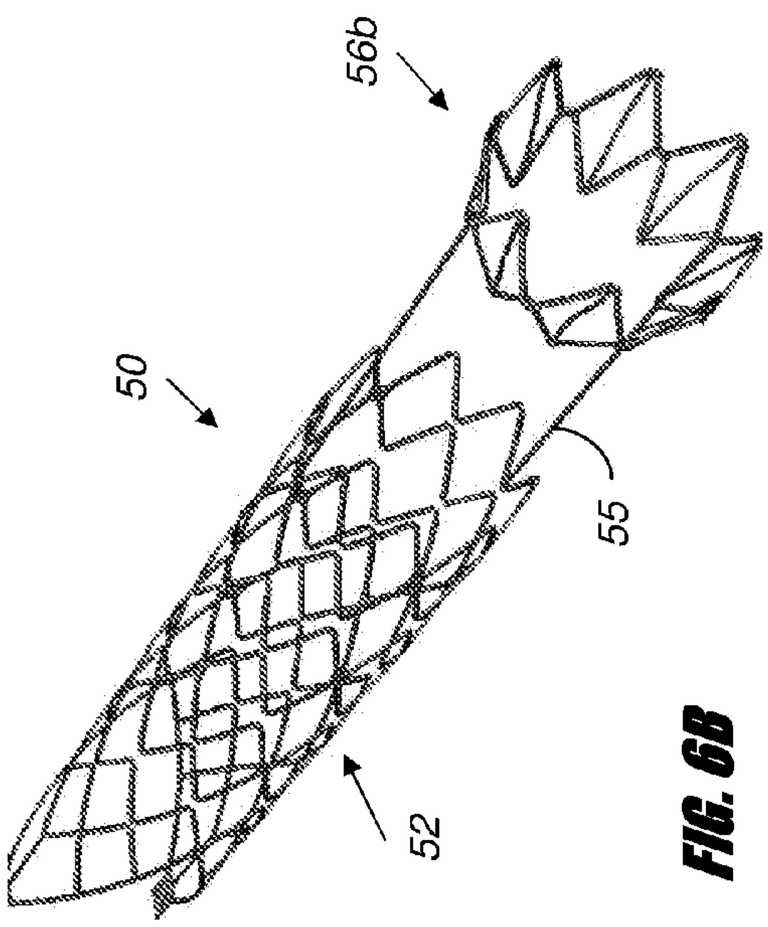

FIG. 6B

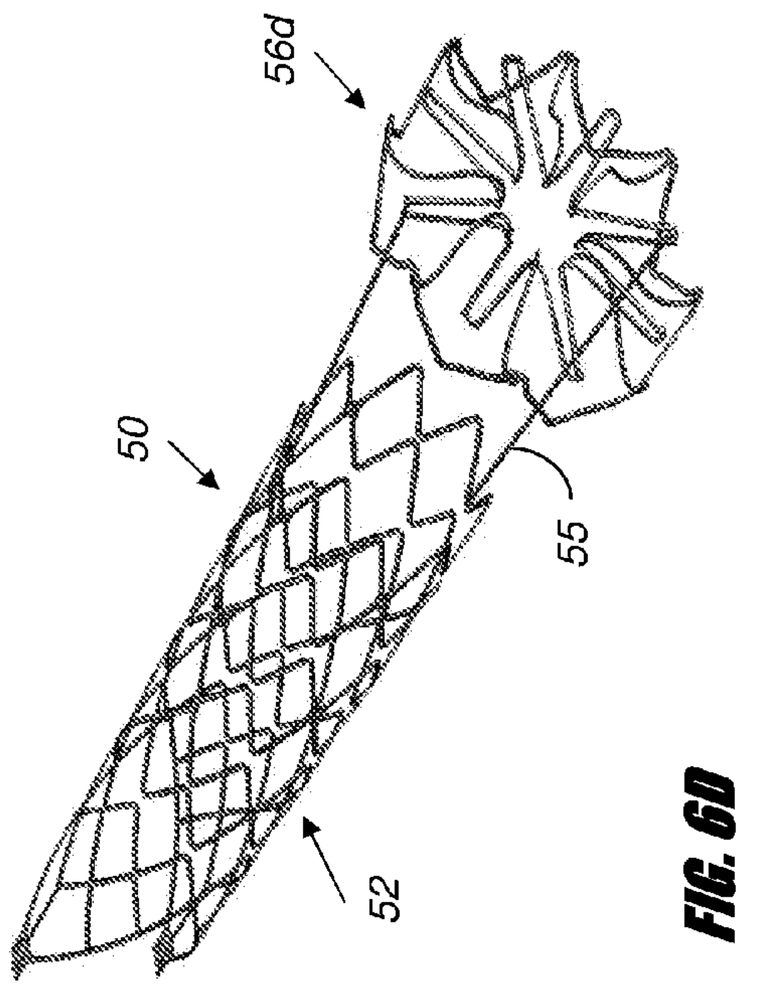

FIG. 6D

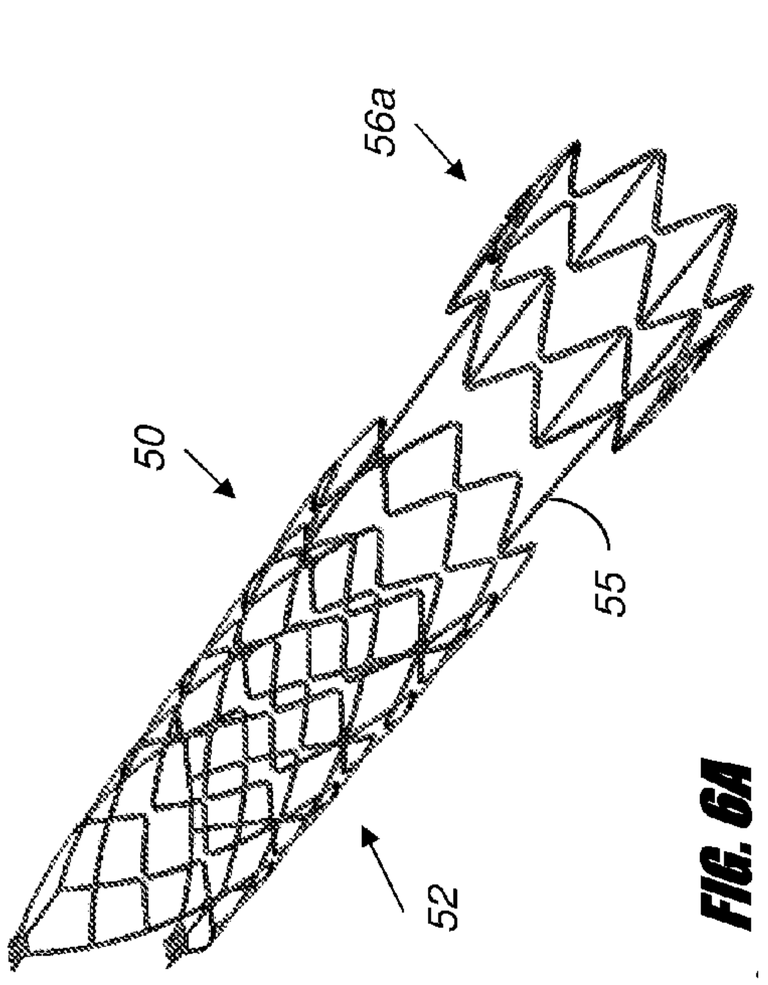

FIG. 6A

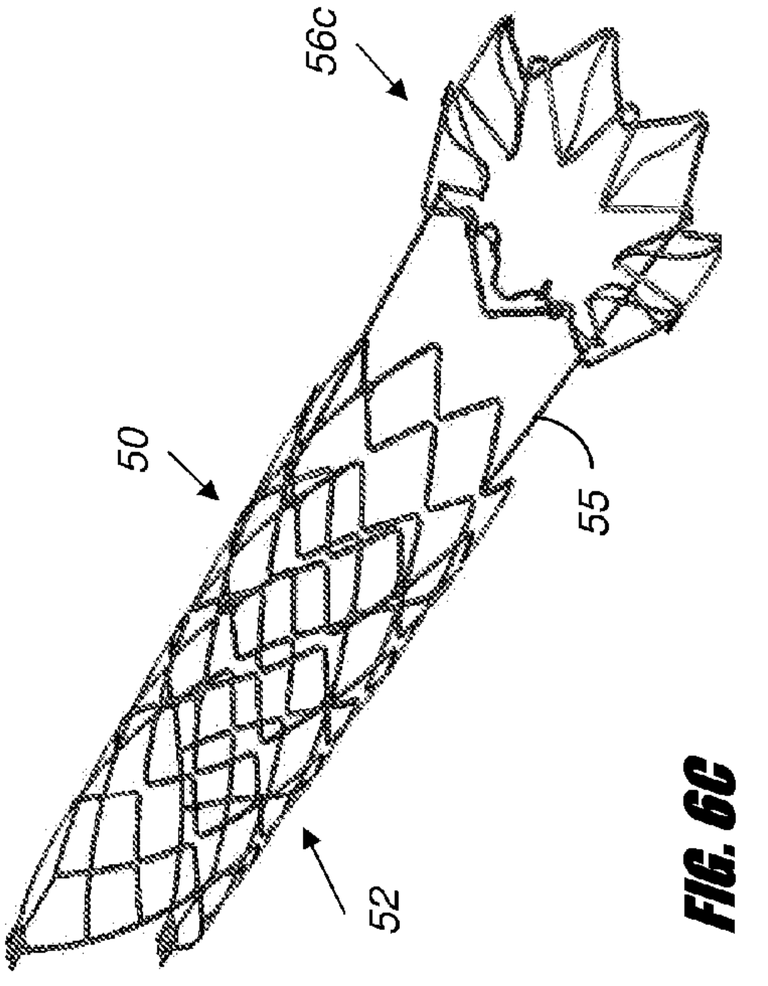

FIG. 6C

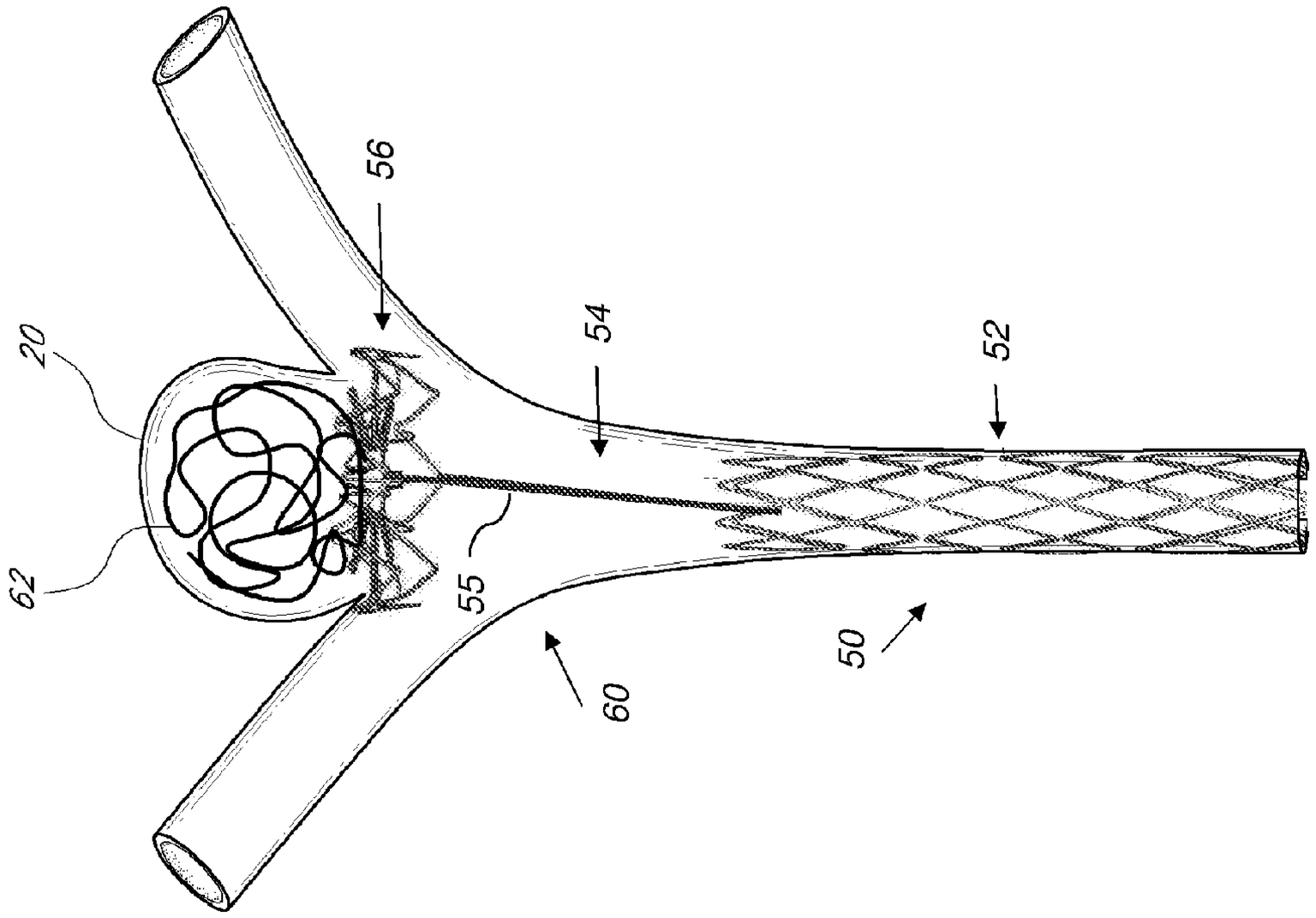

FIG. 7B

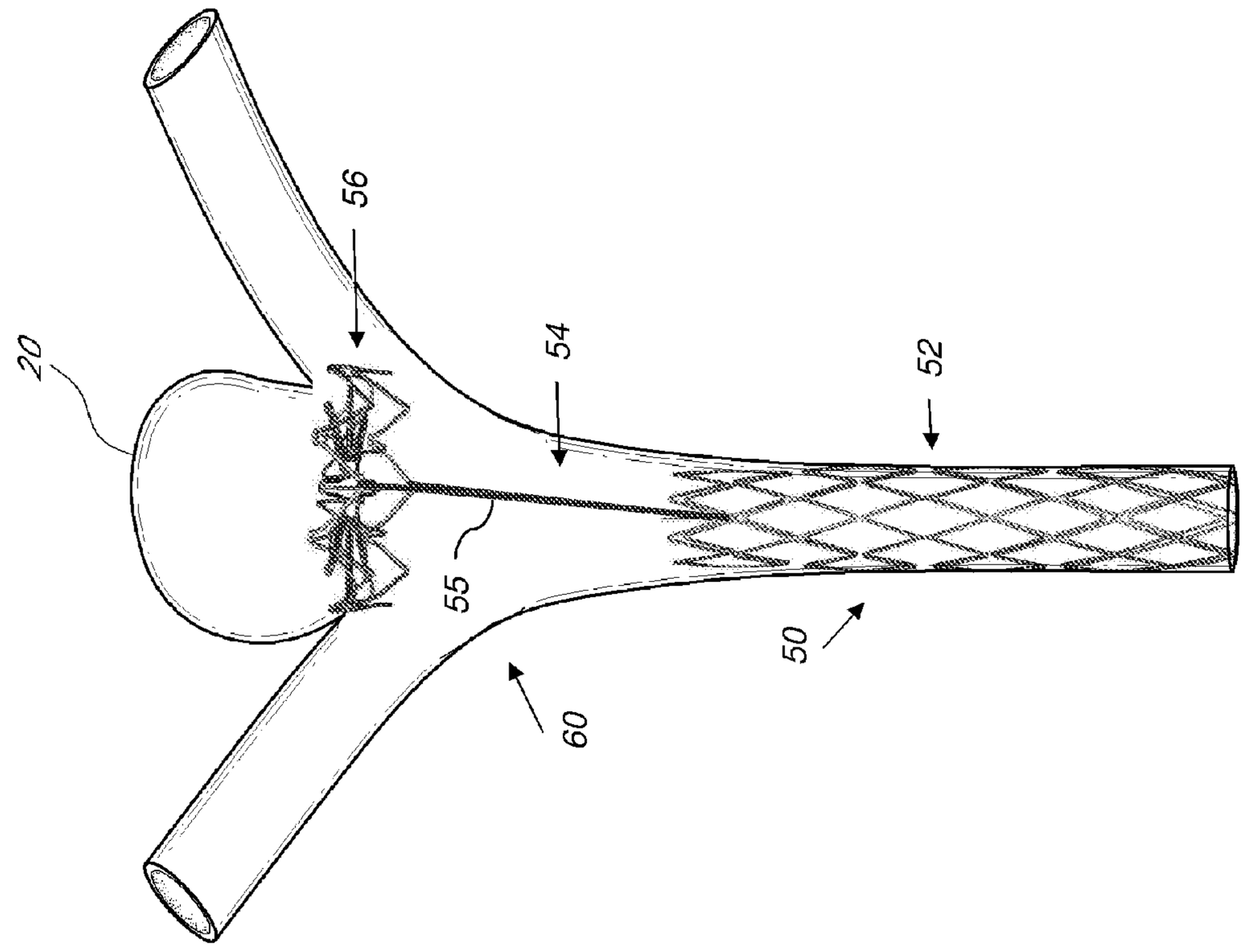

FIG. 7A

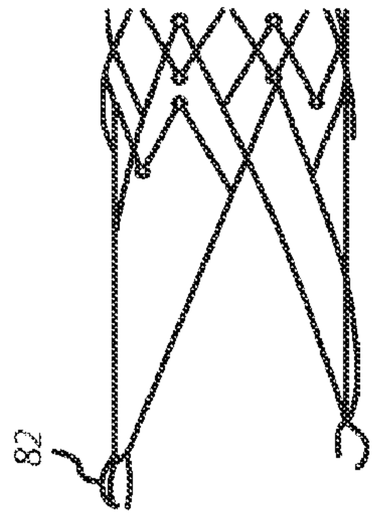

FIG. 8B

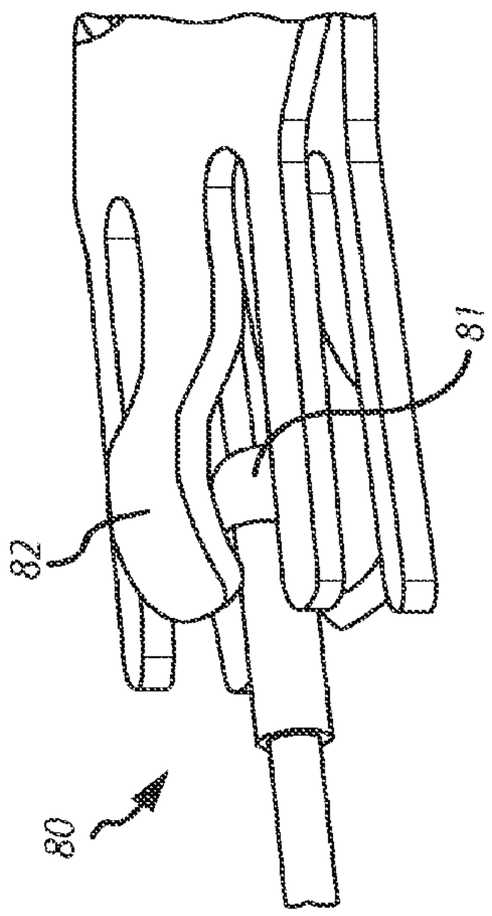

FIG. 8A

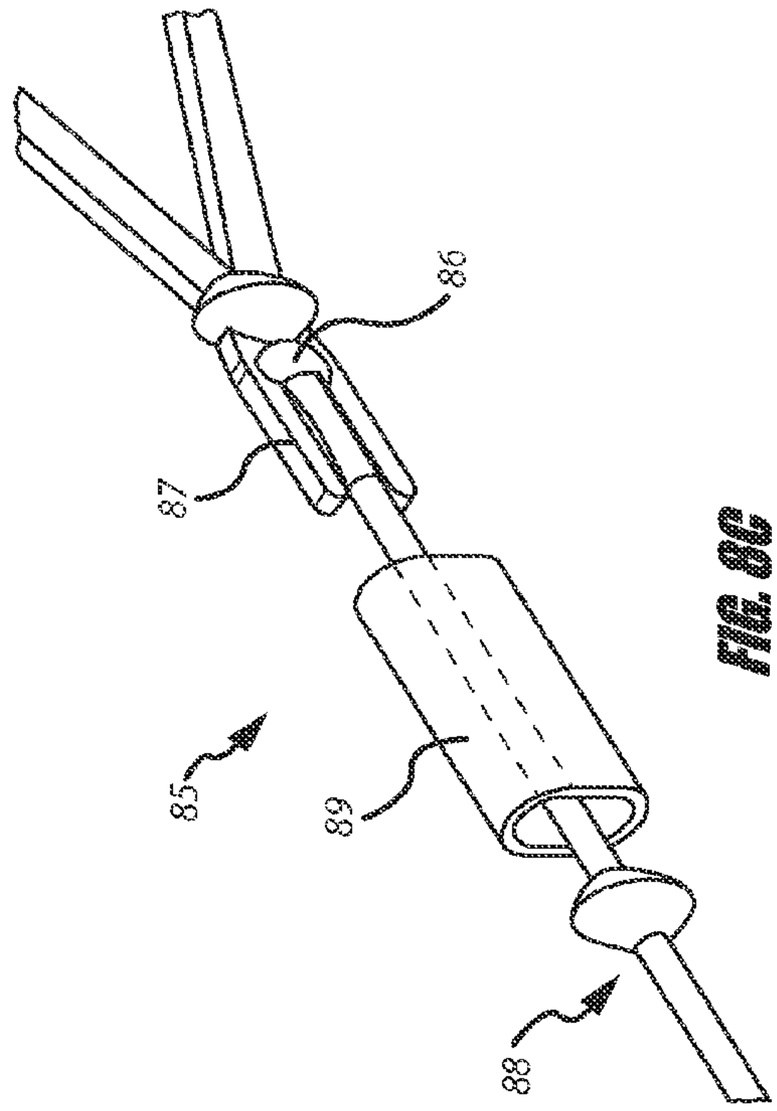

FIG. 8C

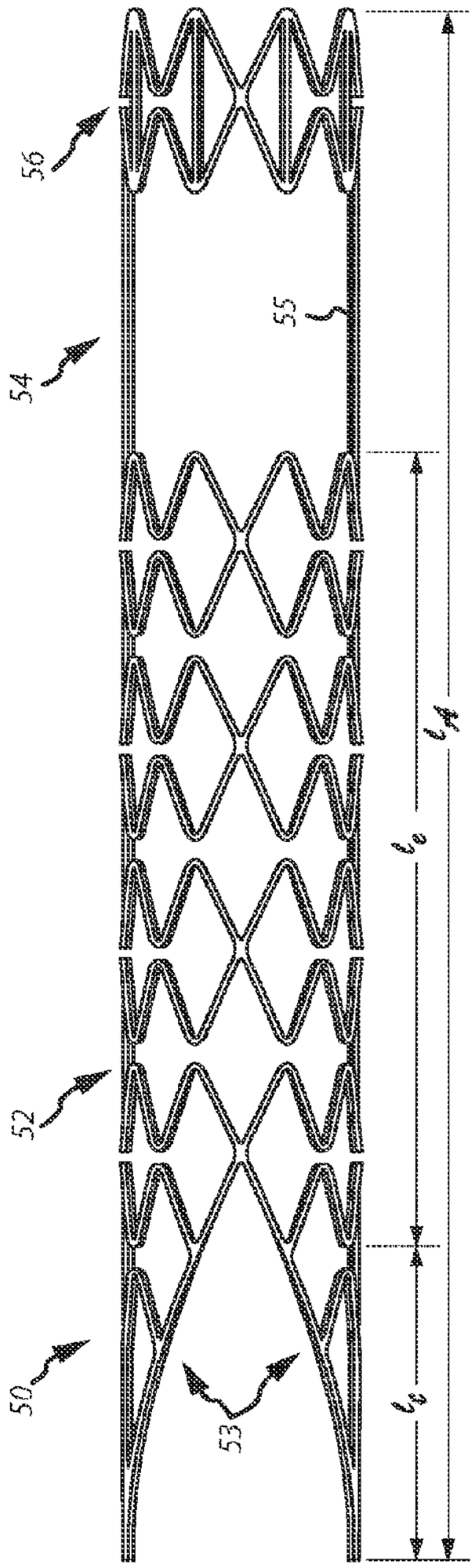
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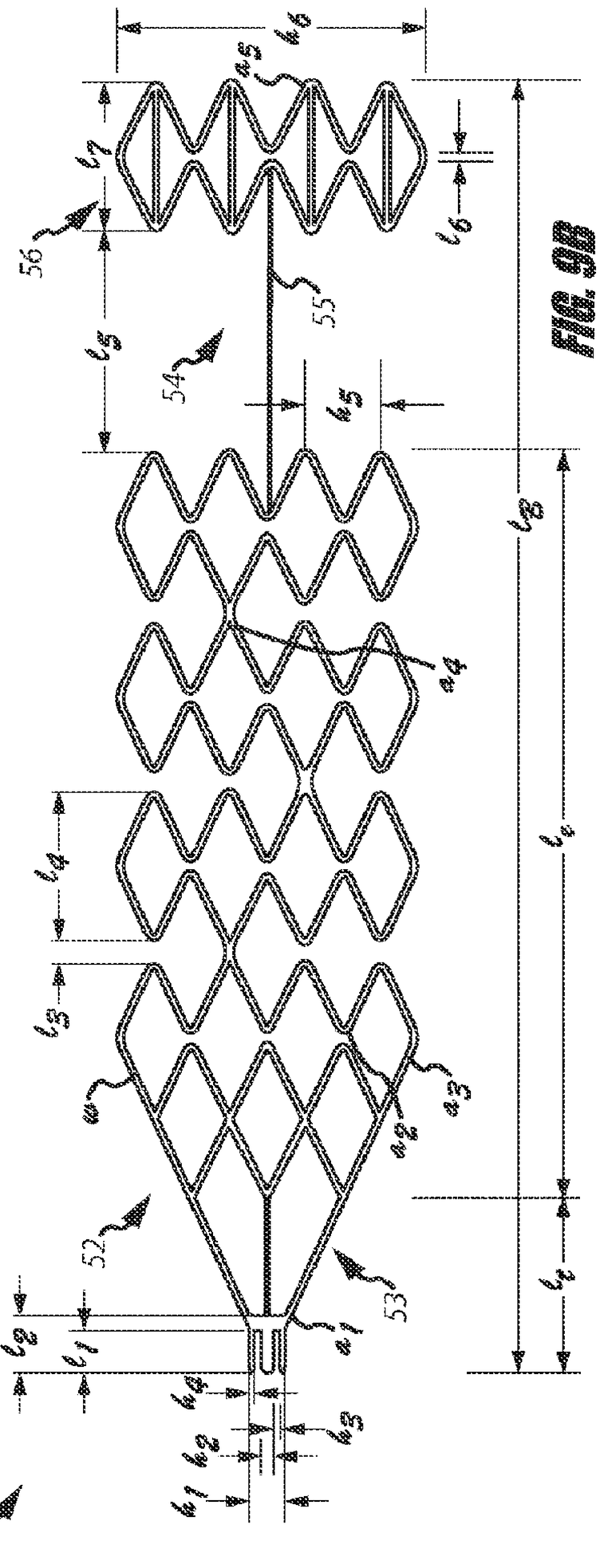
FIG. 9A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b_1
b_2
b_3
b_4
b_5

FIG. 9B

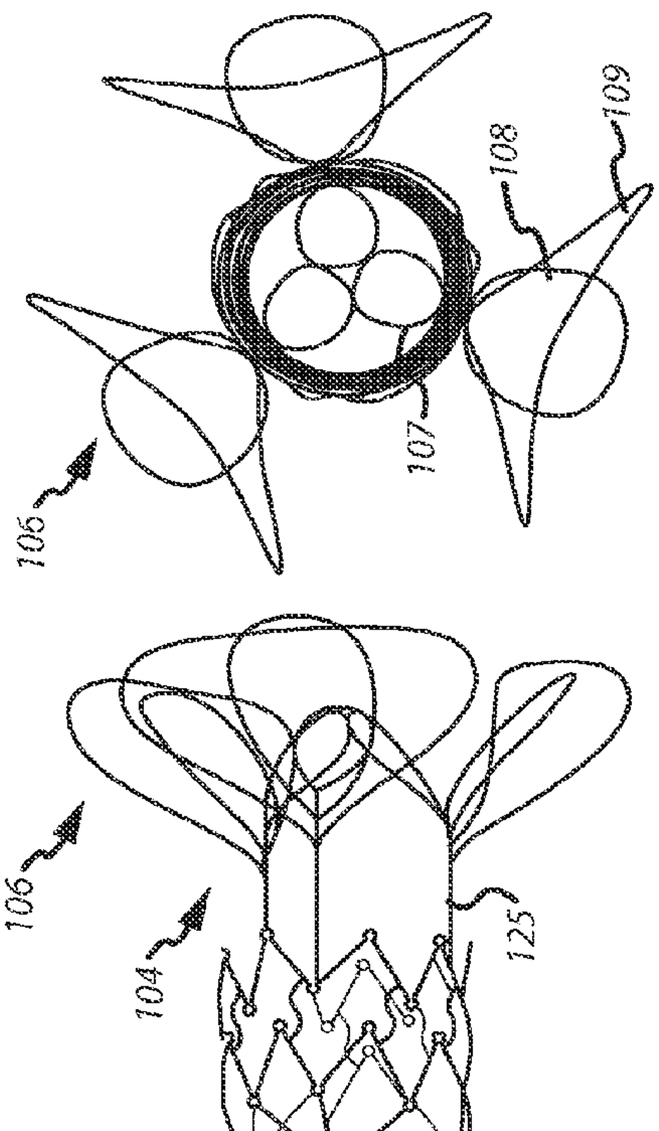

FIG. 10B

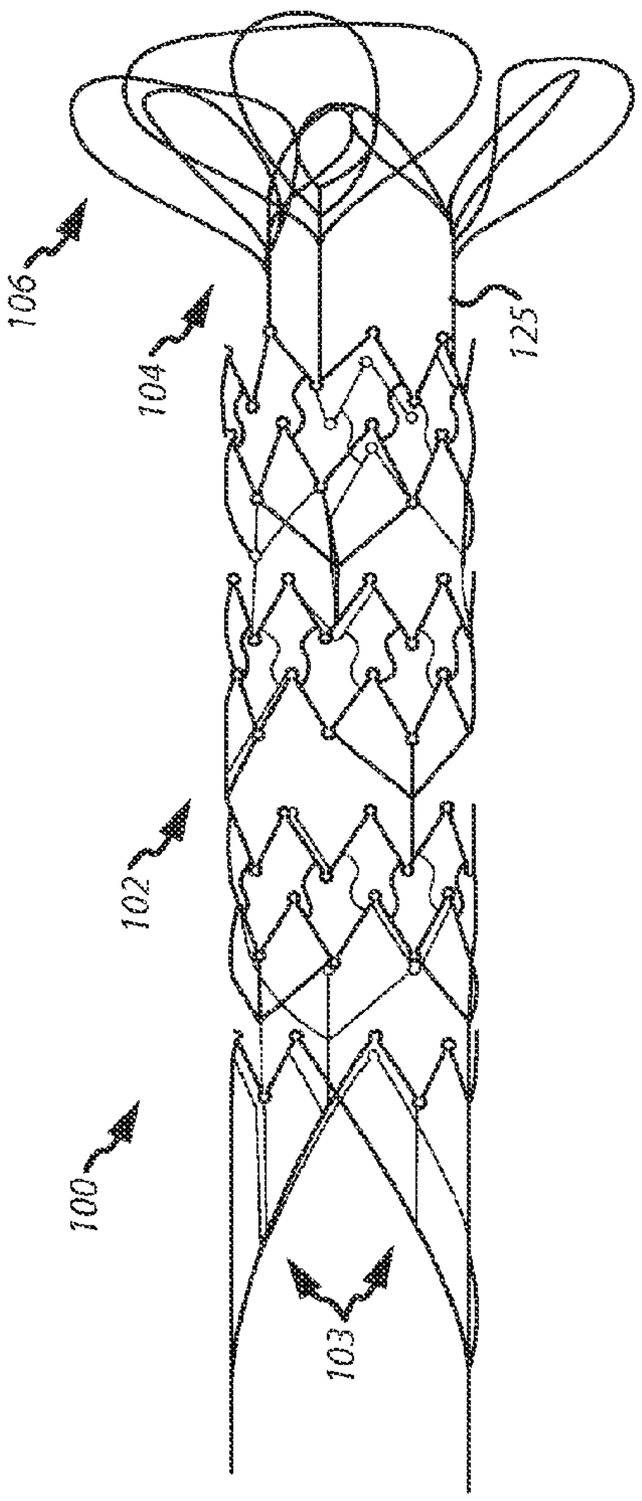

FIG. 10A

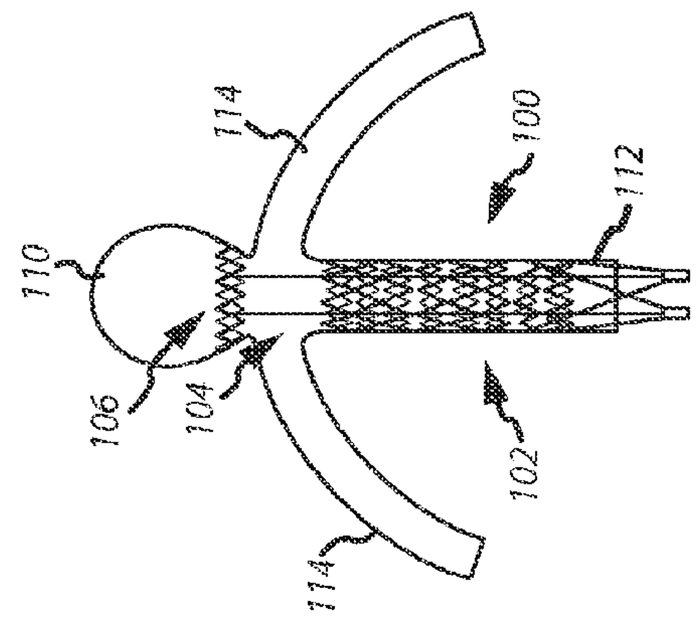

FIG. 11

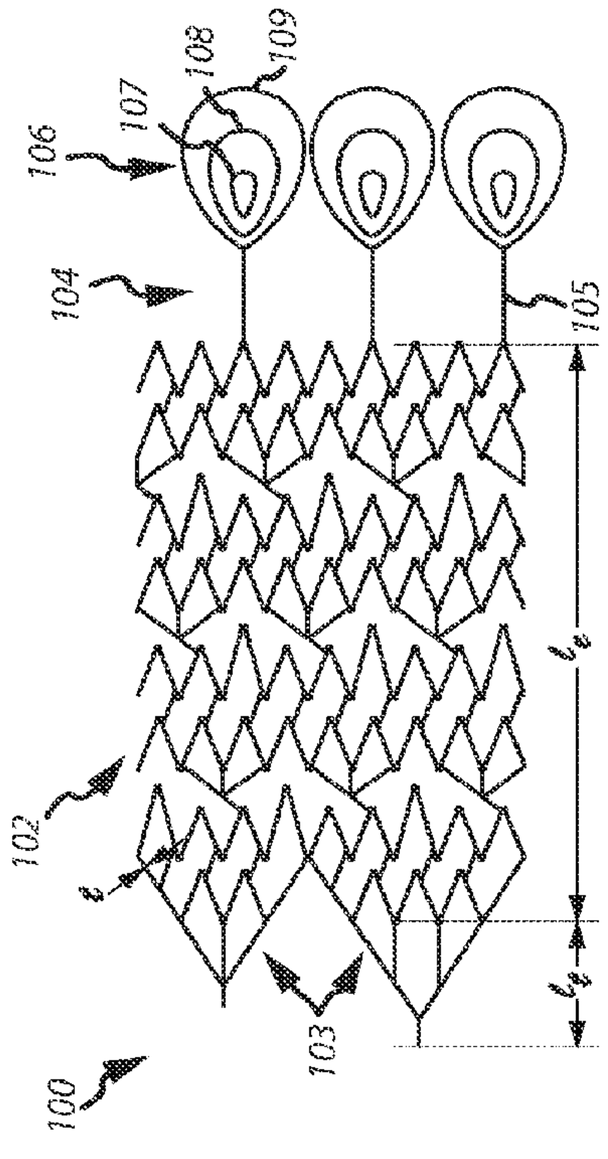

FIG. 10C

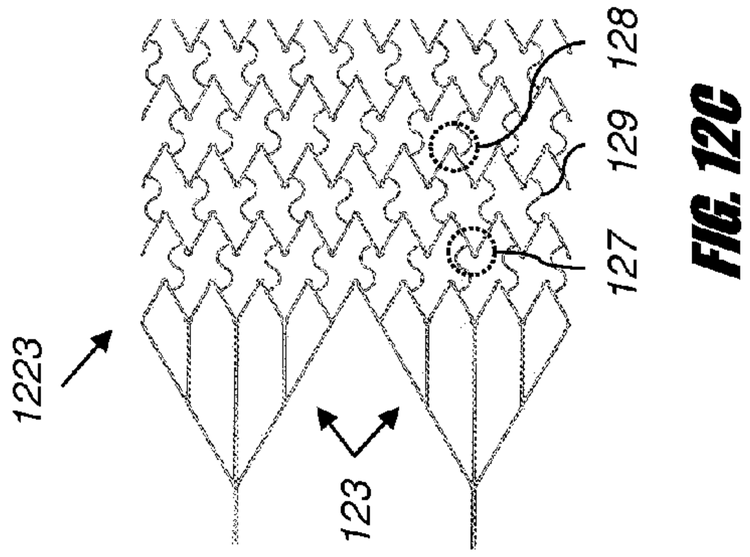

FIG. 12C

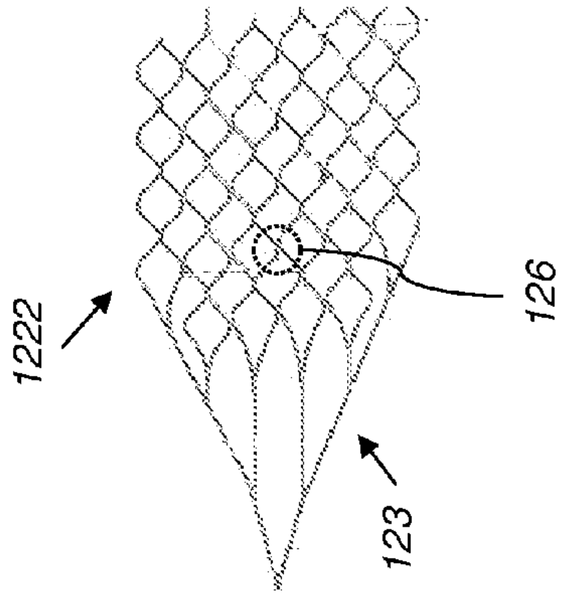

FIG. 12B

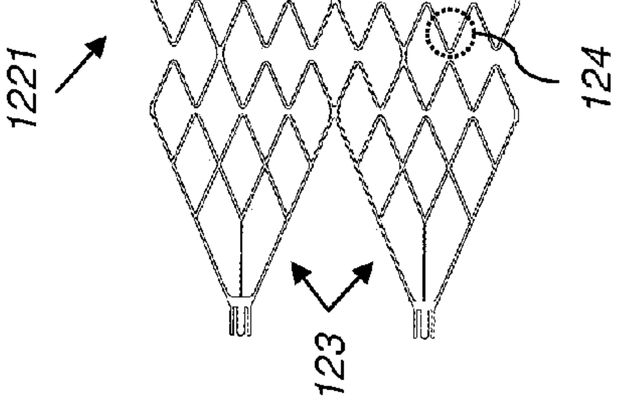

FIG. 12A

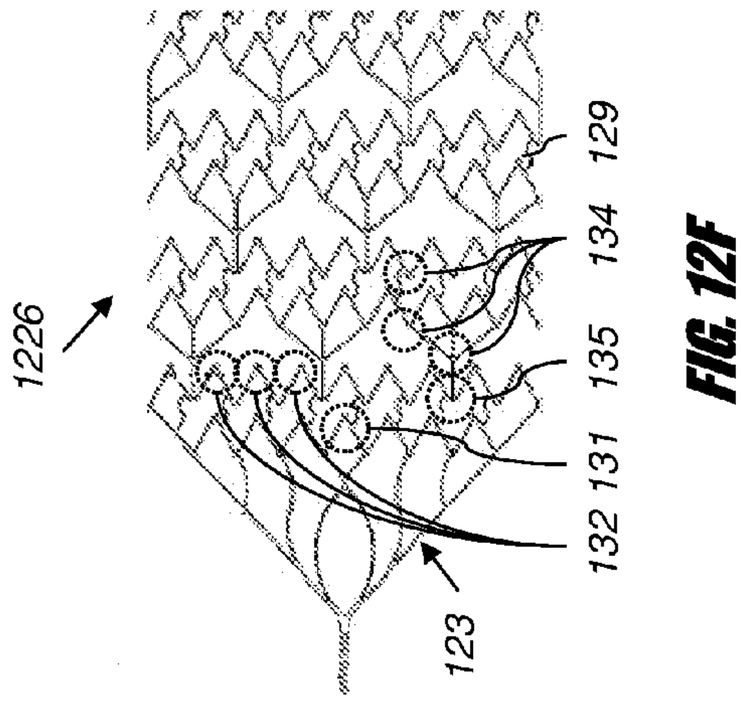

FIG. 12F

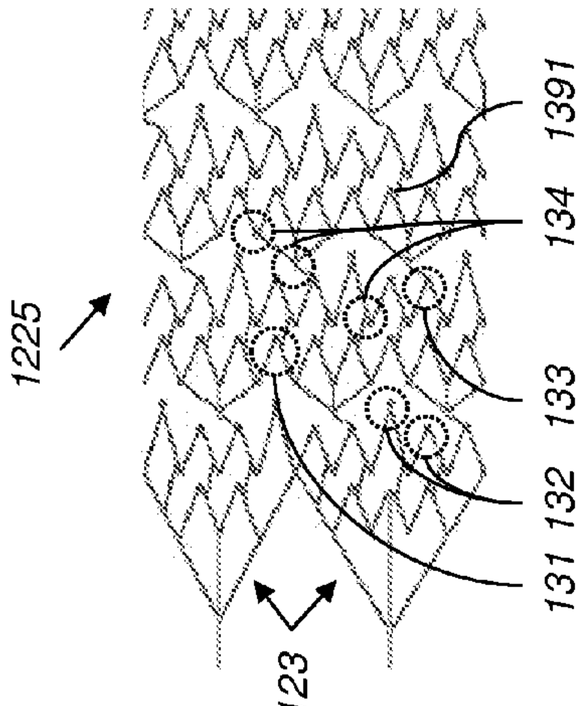

FIG. 12E

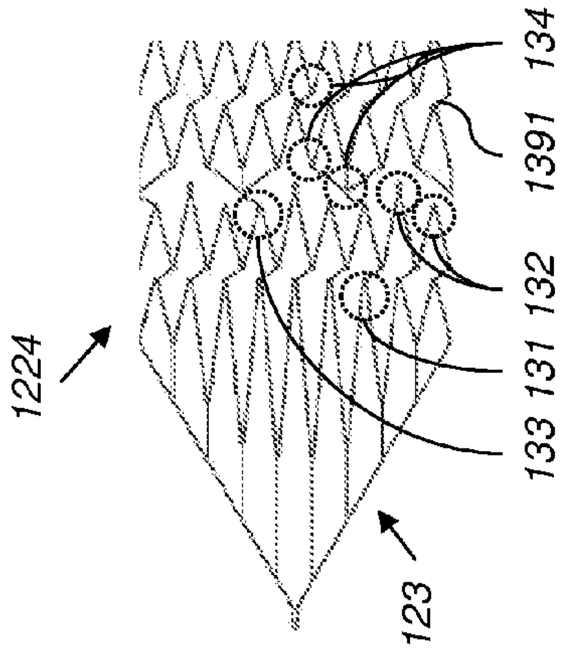

FIG. 12D

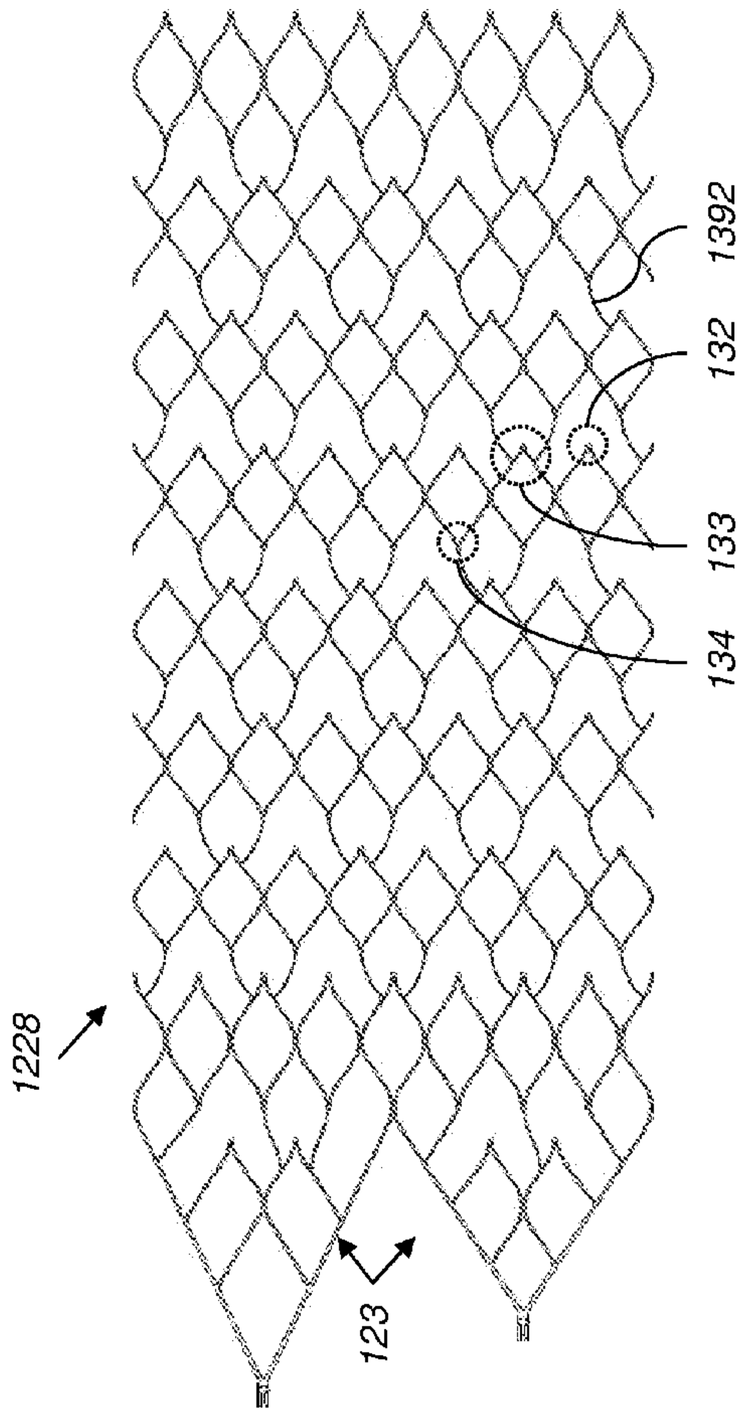

FIG. 12H

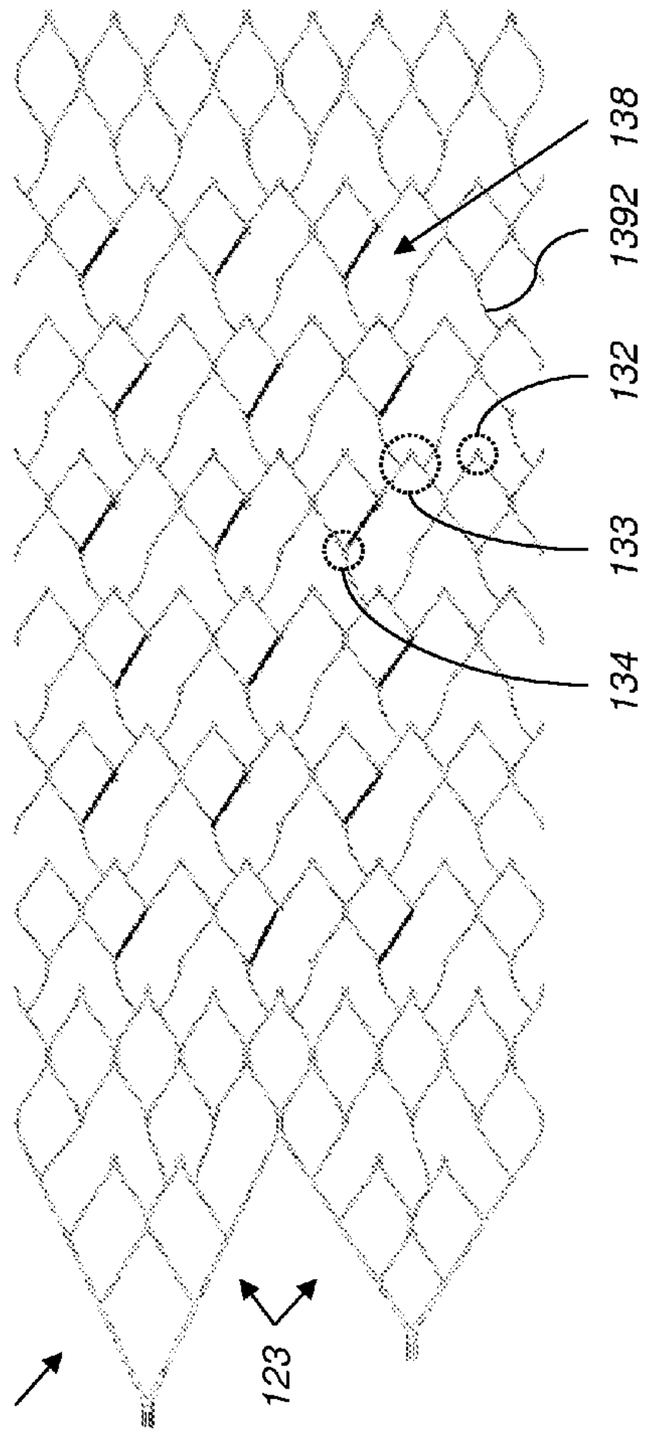

FIG. 12I

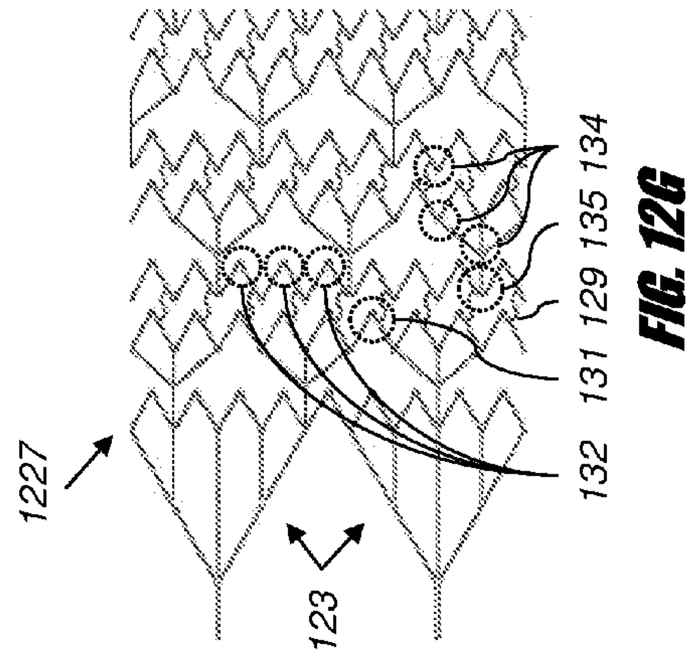

FIG. 12G

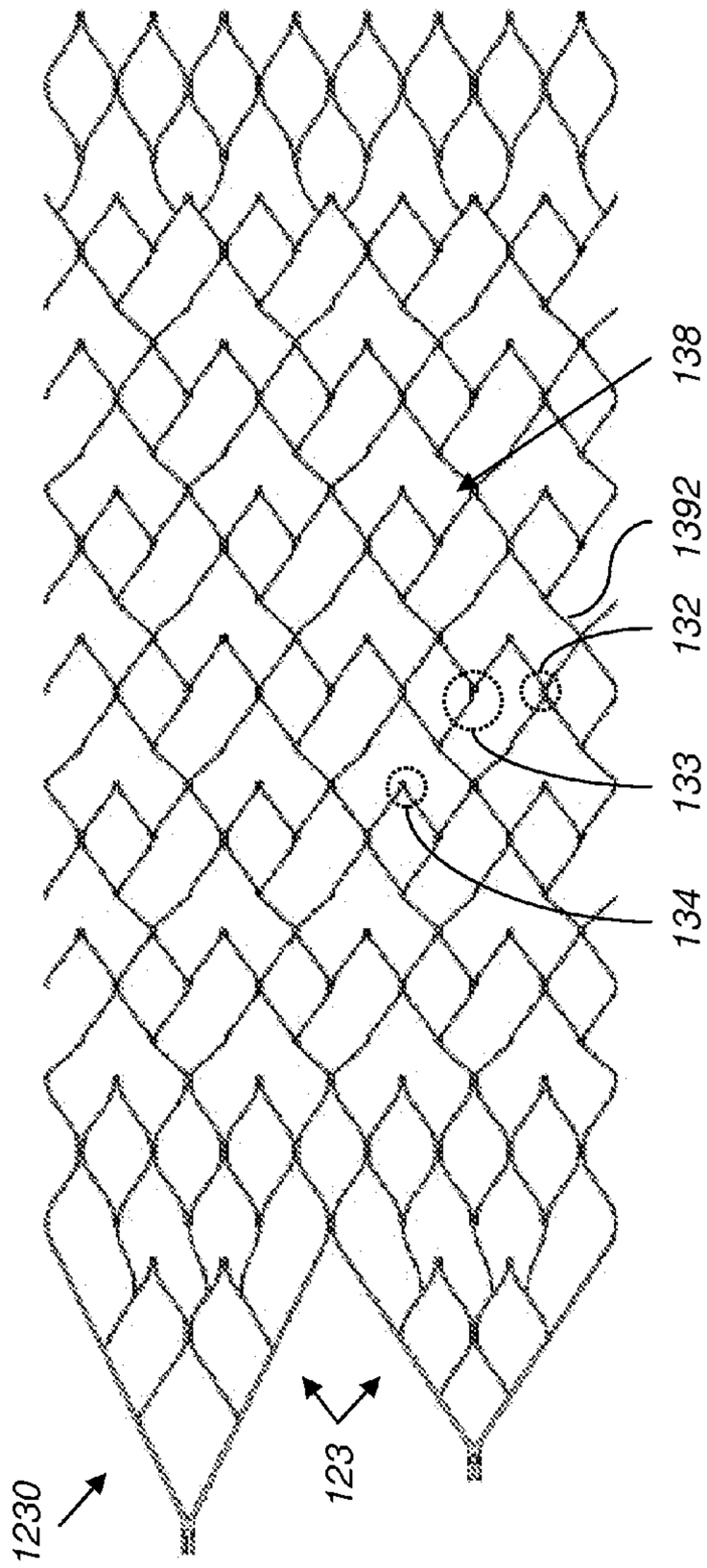

FIG. 12J

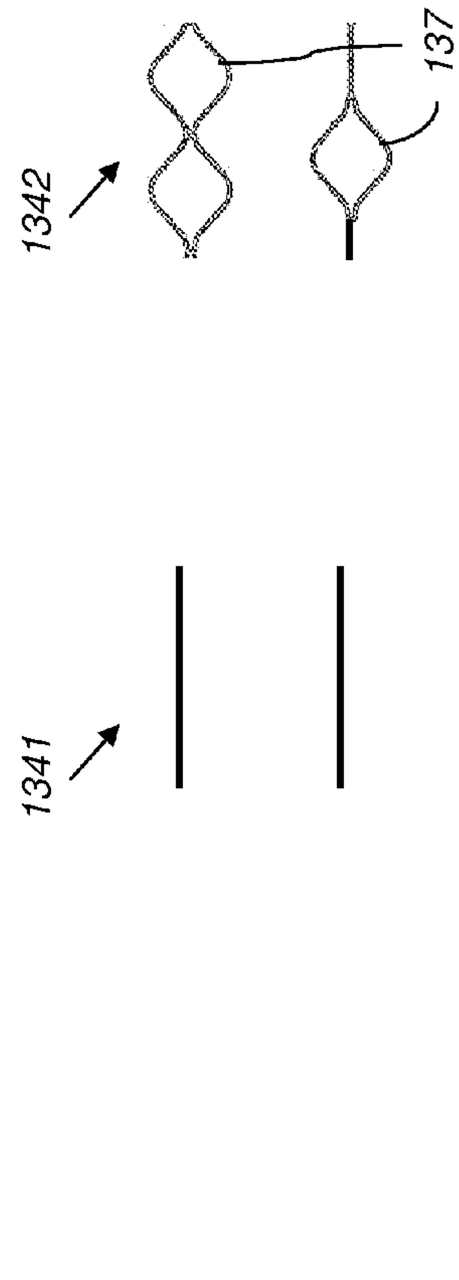

FIG. 13A FIG. 13B

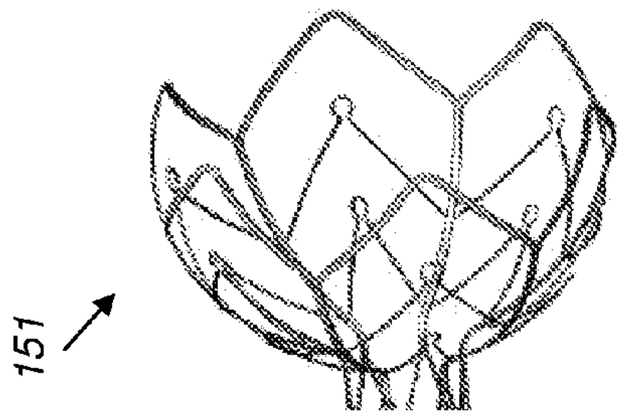

FIG. 15

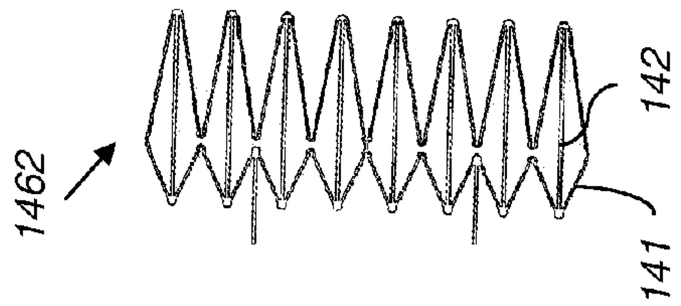

FIG. 14B

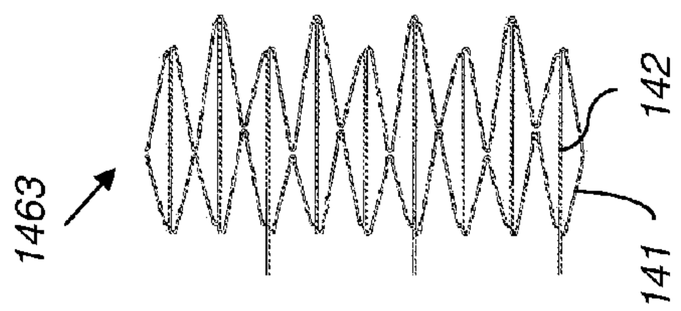

FIG. 14C

FIG. 14A

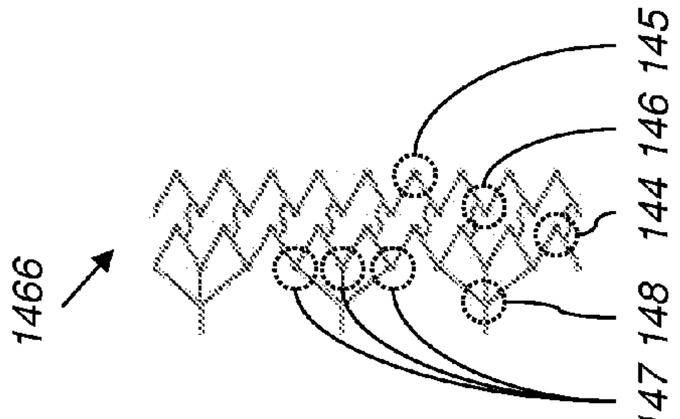

FIG. 14F

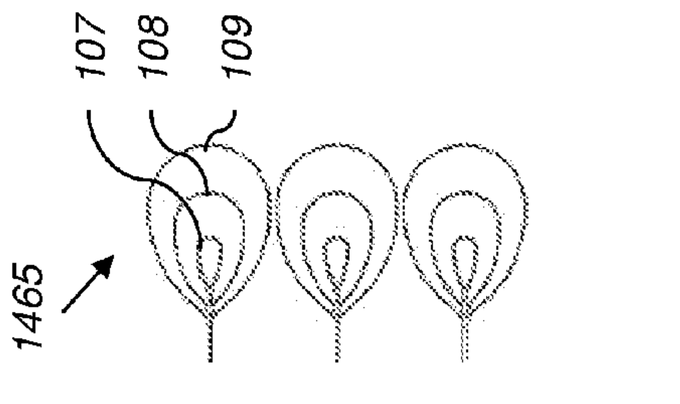

FIG. 14E

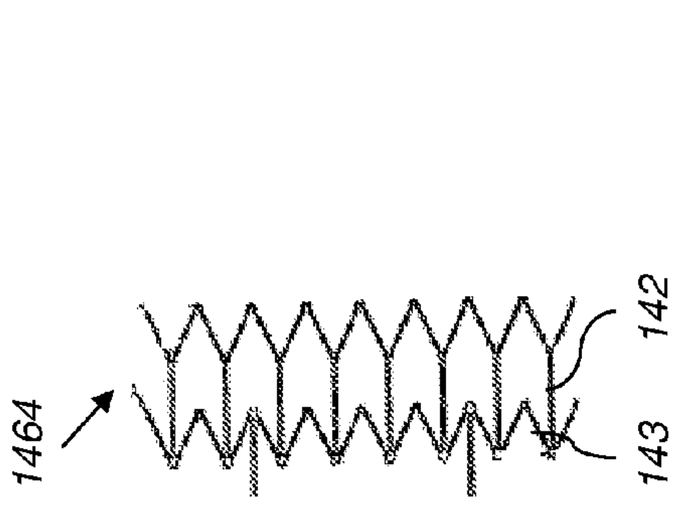

FIG. 14D

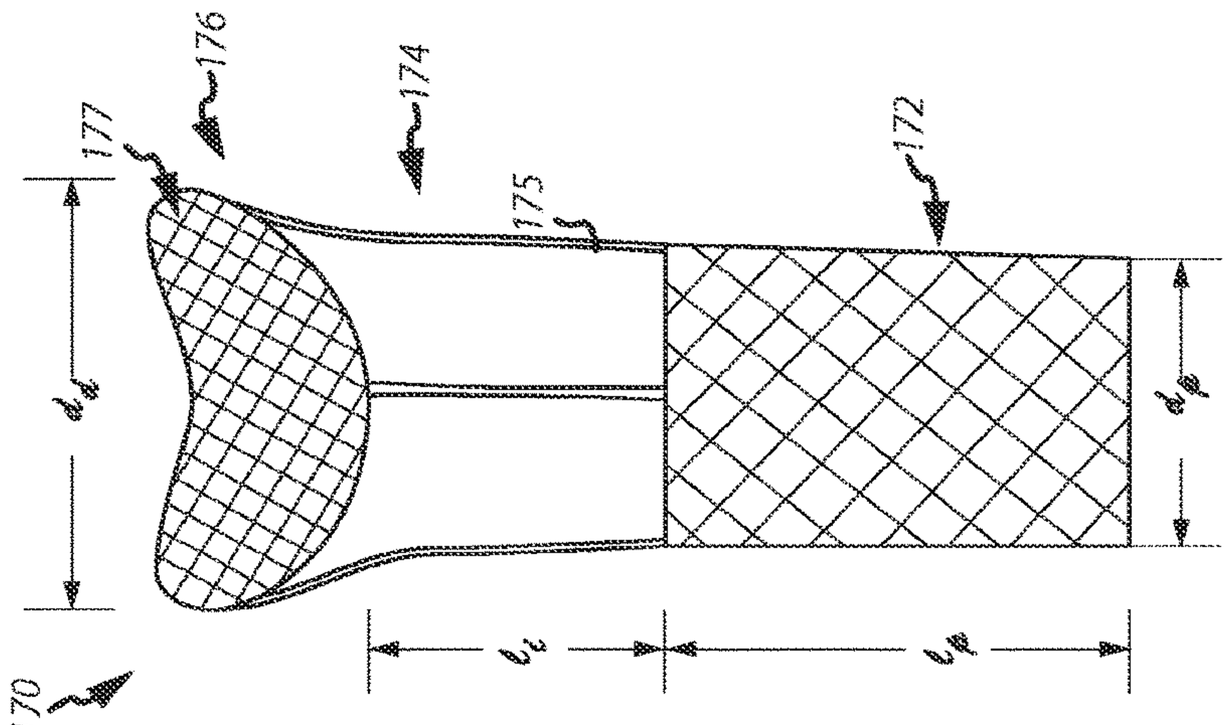

FIG. 17

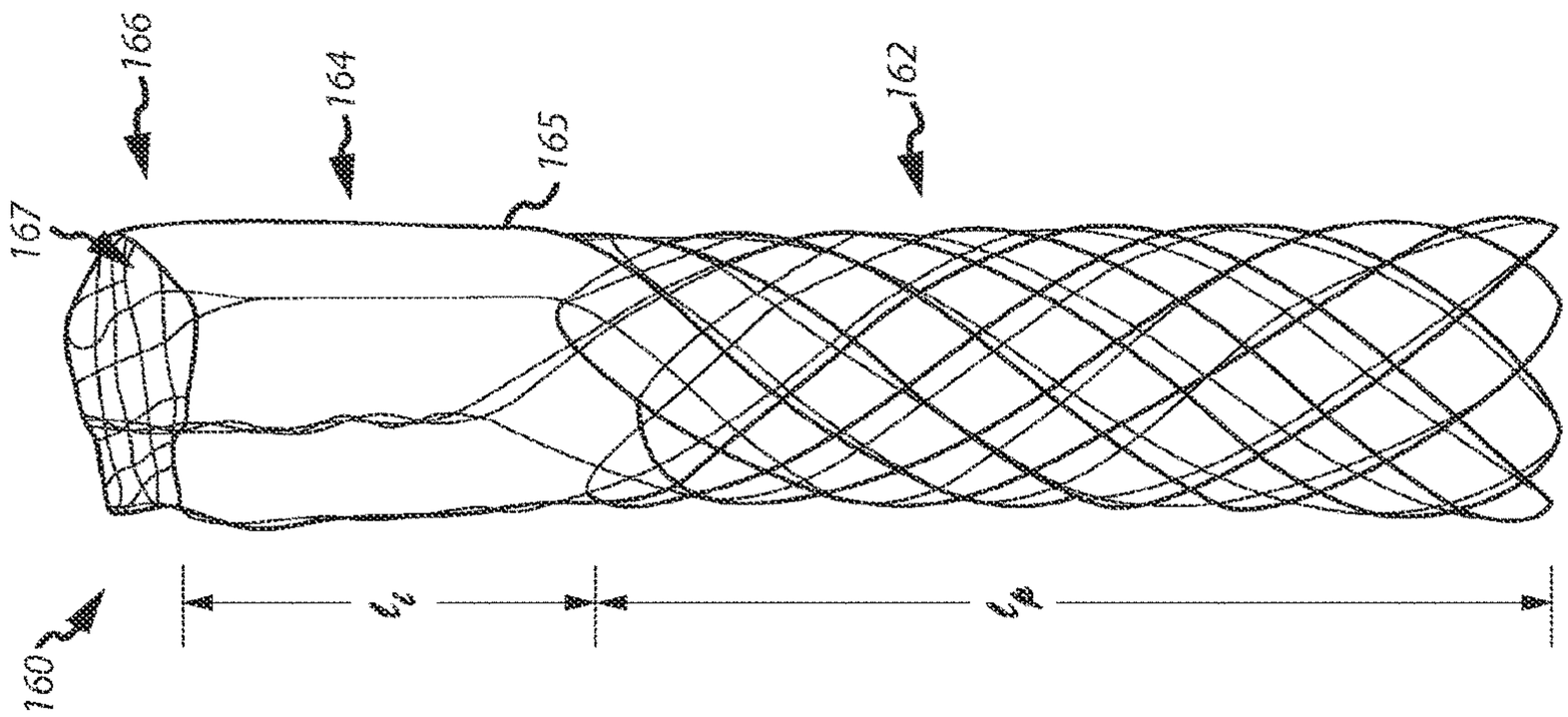

FIG. 16

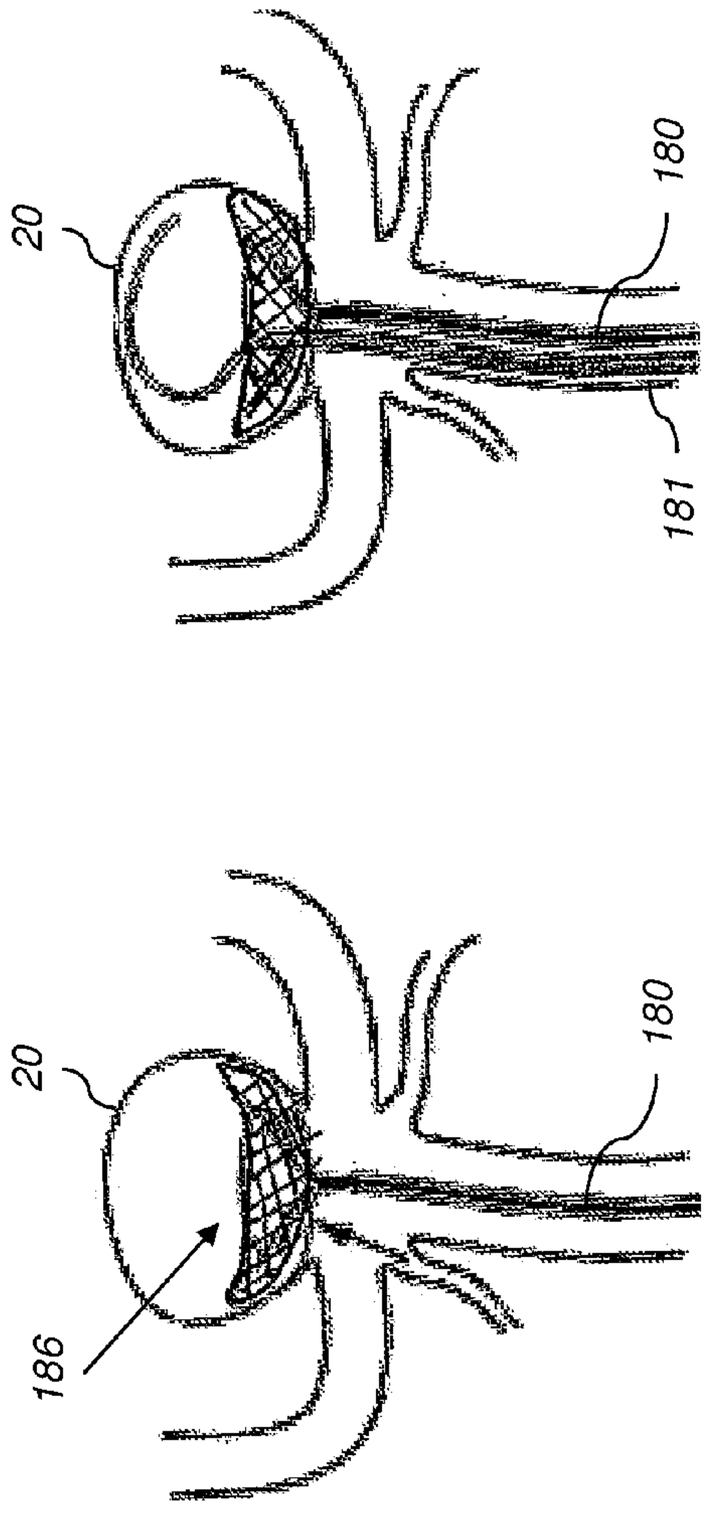

FIG. 18C

FIG. 18B

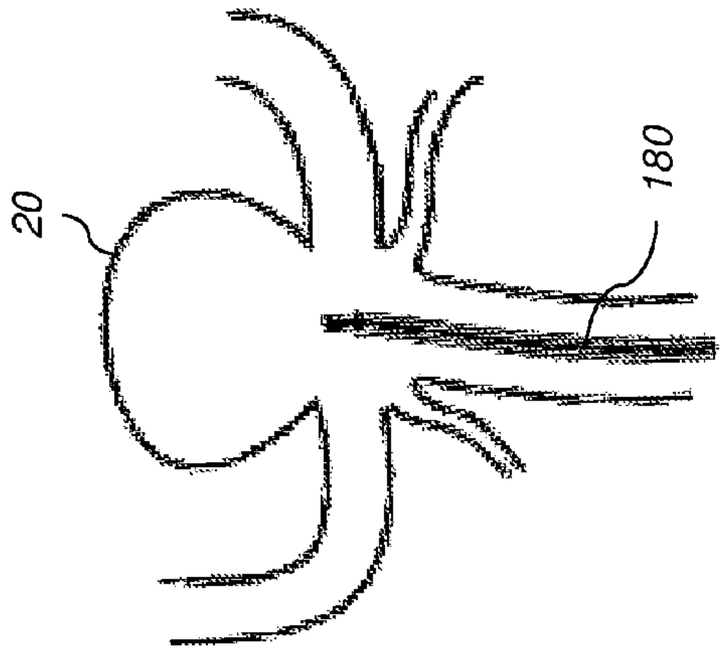

FIG. 18A

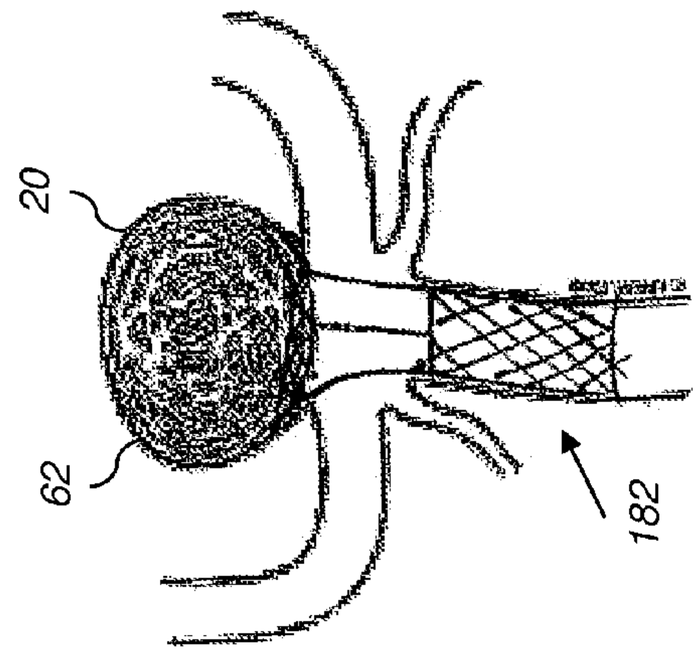

FIG. 18E

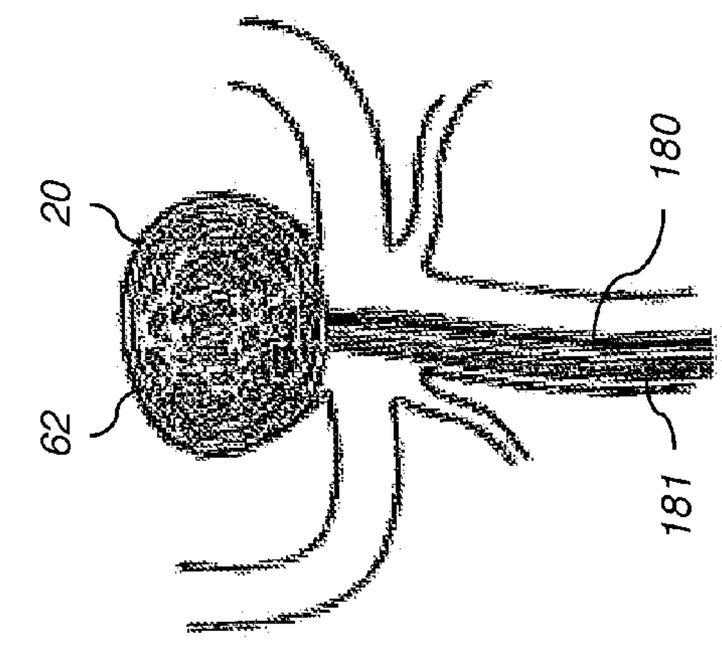

FIG. 18D

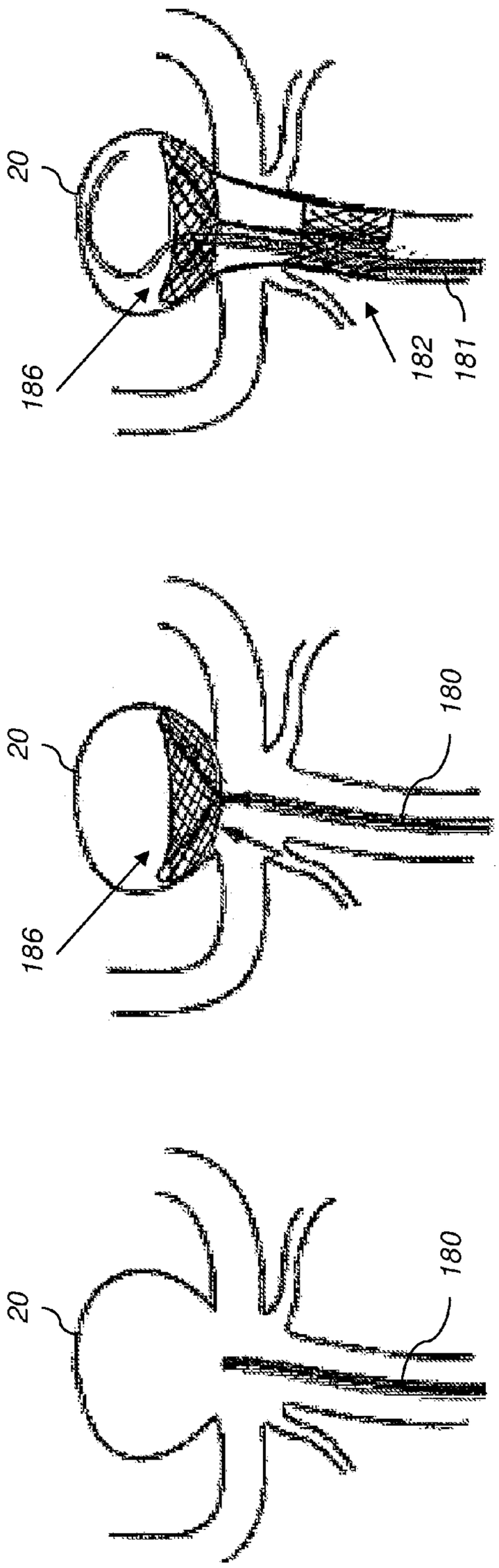

FIG. 19C

FIG. 19B

FIG. 19A

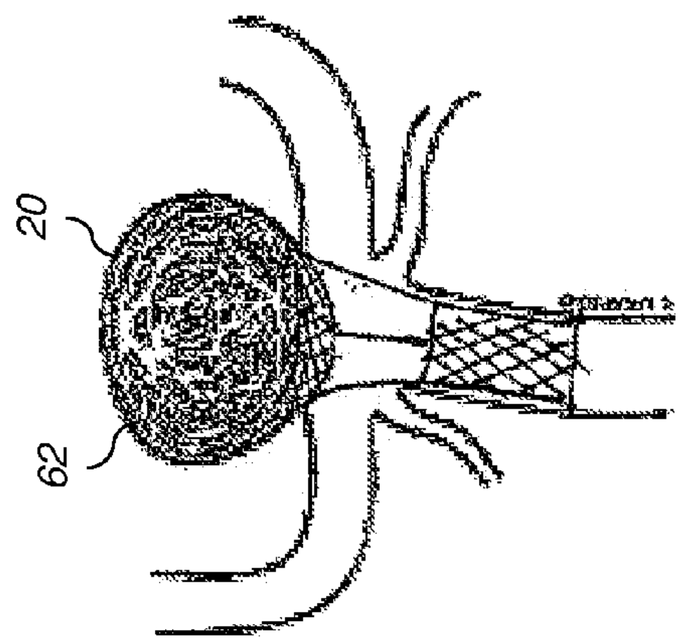

FIG. 19E

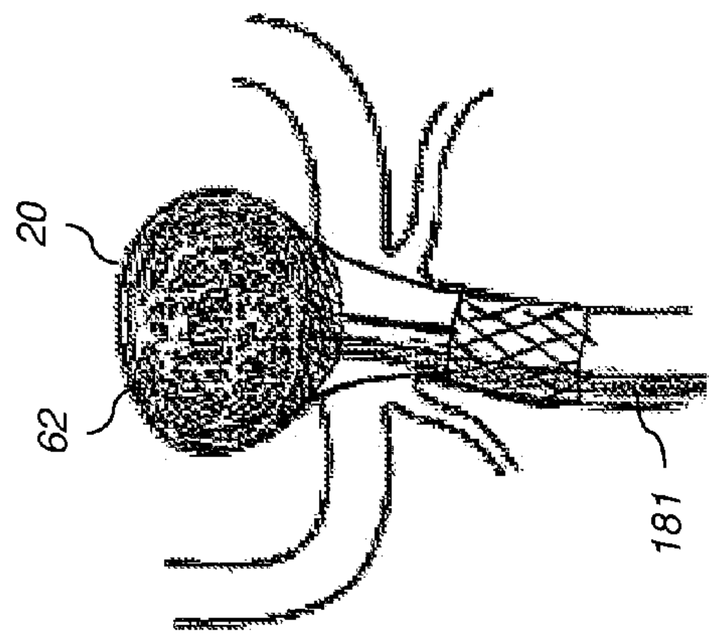

FIG. 19D

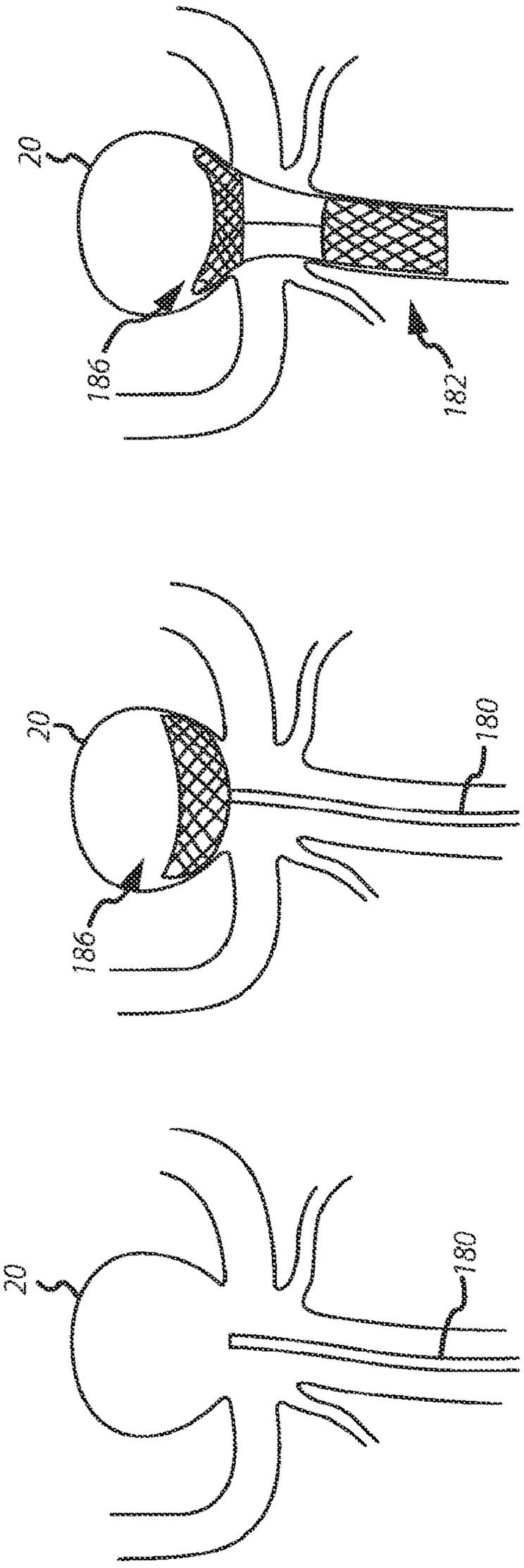

FIG. 20C

FIG. 20B

FIG. 20A

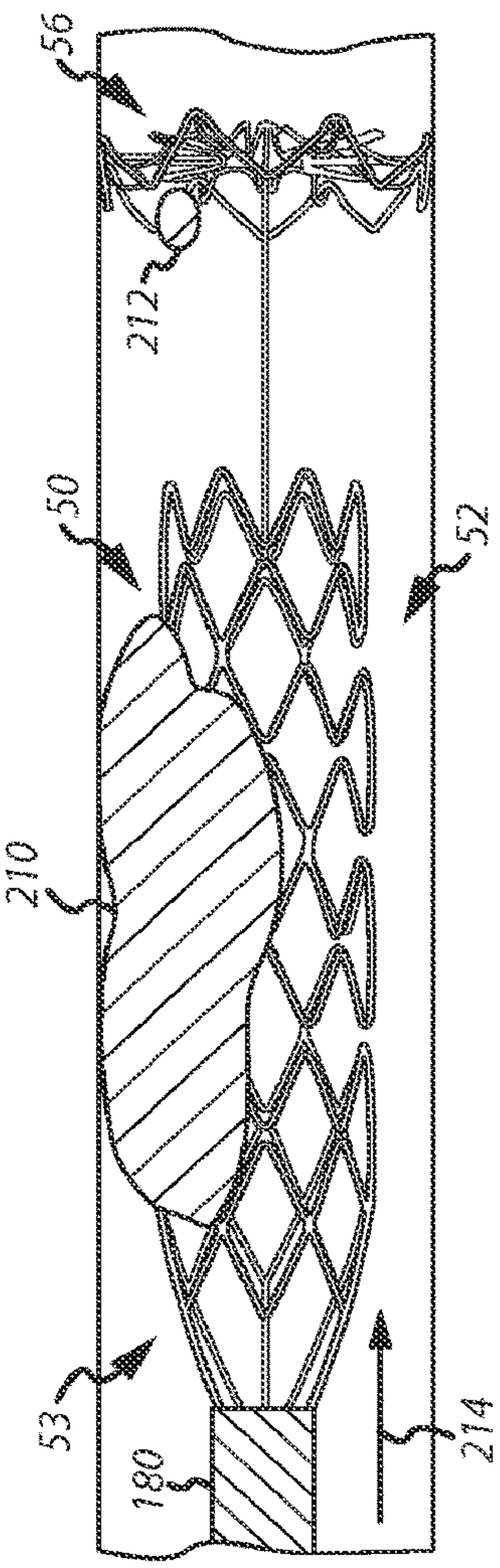

FIG. 21A

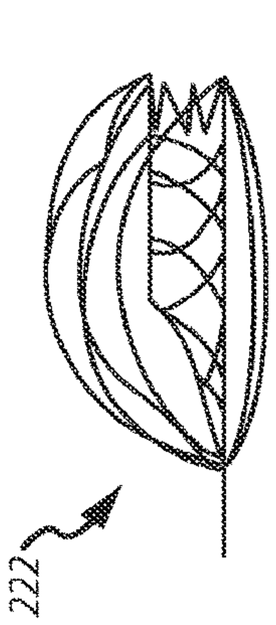

FIG. 22A

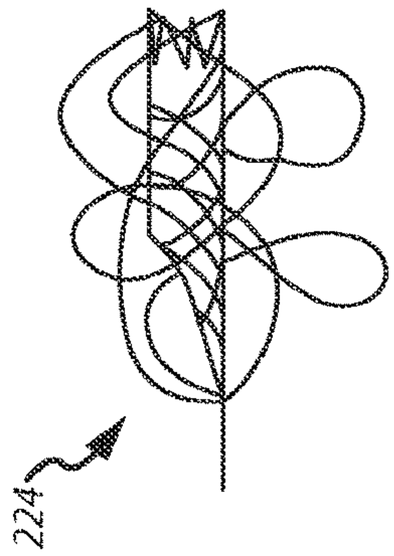

FIG. 22B

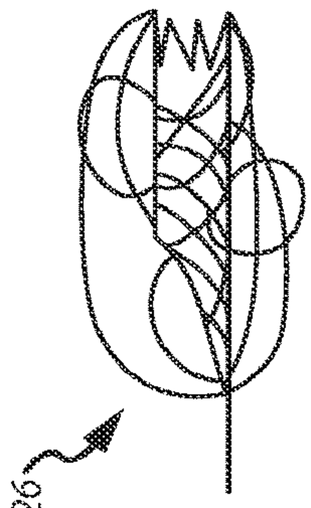

FIG. 22C

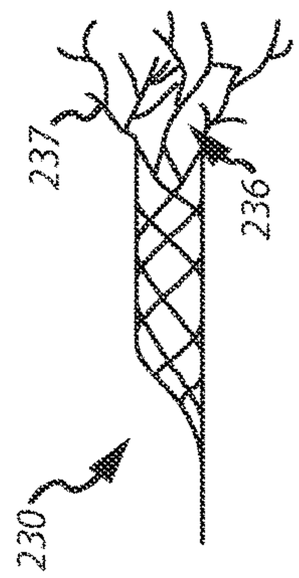

FIG. 23

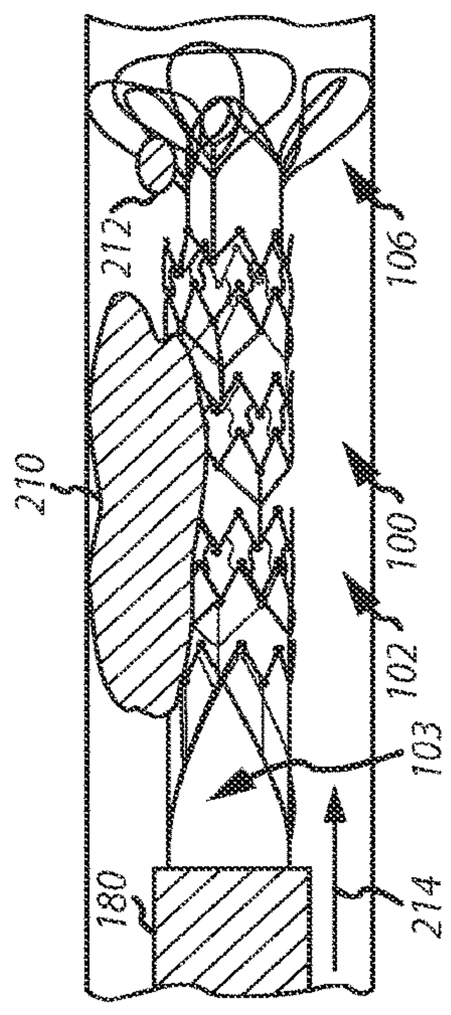

FIG. 21B

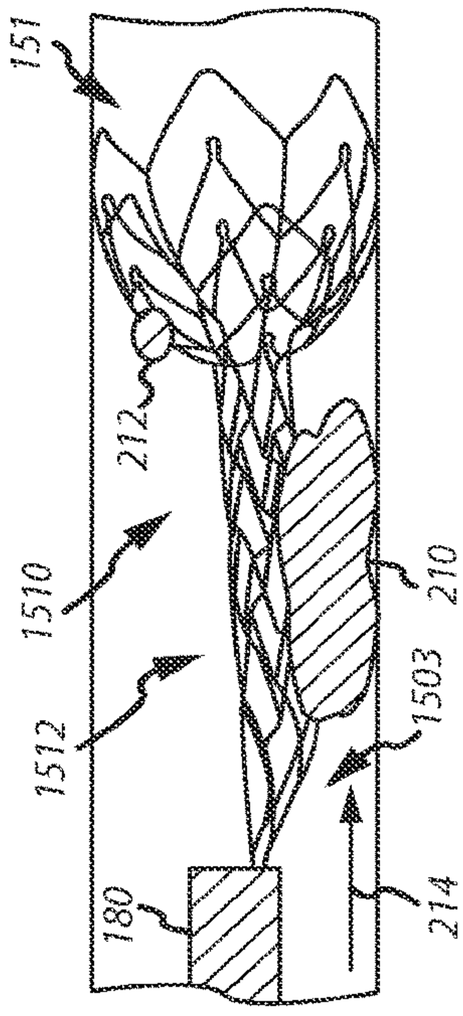

FIG. 21C

VASCULAR REMODELING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. application Ser. No. 13/312,889, filed on Dec. 6, 2011, now U.S. Pat. No. 8,915,950, which claims priority to U.S. Provisional Patent App. No. 61/420,275, filed Dec. 6, 2010 and U.S. Provisional Patent App. No. 61/448,506, filed Mar. 2, 2011. The entire contents of each of the foregoing applications are hereby incorporated by reference in their entirety.

BACKGROUND

Field

The subject technology relates generally to vascular remodeling devices and to the manner of their positioning in vessels, and, more particularly, to remodeling devices having scaffolding distal sections and to the manner of their positioning at the junction of neurovascular bifurcations having an aneurysm and to remodeling devices having embolic protecting distal sections and to the manner of their use for clot retrieval.

Description of Related Art

Neurovascular or cerebral aneurysms affect about 5% of the population. Aneurysms may be located, for example, along arterial side walls (e.g., the aneurysm **10** illustrated in FIG. **1**) and at arterial bifurcations (e.g., the aneurysm **20** illustrated in FIG. **2**). The direction of fluid flow is generally indicated by the arrows **16**, **26**. The aneurysms **10**, **20** each have a fundus **12**, **22**, a neck **14**, **24**, and a fundus-to-neck ratio or "neck ratio." If the neck ratio is greater than 2 to 1 or if the neck **14**, **24** is less than 4 mm, the aneurysm **10**, **20** may be treated with embolization coils alone because the coils will generally constrain themselves within the aneurysm **10**, **20** without herniating into parent vessels. If the neck ratio is less than 2 to 1 or if the neck **14**, **24** is greater than 4 mm, the aneurysms **10**, **20** may be difficult to treat with embolization coils alone because the coils may be prone to herniating into parent vessels, as illustrated in FIG. **3**A and FIG. **3**B. Herniation of coils **18**, **28** may cause arterial occlusion, stroke, and/or death. Compared to the bifurcation illustrated in FIG. **2**, the efferent vessels of the bifurcation may be at substantially different angles, have substantially different sizes, and/or be a different quantity (e.g., three or more). Compared to the bifurcation illustrated in FIG. **2**, the aneurysm **20** of the bifurcation may be offset with respect to the junction (e.g., having a neck substantially open to one efferent vessel), tilted with respect to a plane created by the vessels (e.g., into or out of the page), etc. Moreover, vasculature may include more than two efferent vessels (e.g., three efferent vessels in a trifurcation). Each of these would still be accurately characterized as a "bifurcation" herein.

In order to inhibit such herniation, tubular neck remodeling devices, for example Neuroform®, available from Boston Scientific, and Enterprise™, available from Cordis Neurovascular, may be used to keep coils or other materials within the fundus of the aneurysm and out of the vessels. Tubular remodeling devices generally consist of a braided wire or cut metallic stent or stents covering the neck of the aneurysm so that materials introduced into the fundus of the aneurysm do not herniate out of the aneurysm. As illustrated in FIG. **4**A, tubular remodeling devices **40** are generally useful for side wall aneurysms **10**. As illustrated in FIG. **4**B and FIG. **4**C, tubular remodeling devices **42**, **44** are generally less useful for aneurysms **20** at bifurcations (e.g., the basilar tip area), for example because positioning/shaping the remodeling devices to preserve blood flow through the afferent and efferent vessels while also inhibiting herniation of coils **28** out of the aneurysm **20** can be difficult.

SUMMARY

In some embodiments described herein, an intraluminal vascular remodeling device or stent includes a tubular proximal portion and a distal portion. The proximal portion has an open cell design, a closed cell design, or a hybrid cell design having no reverse free-peaks for retrievability, good flexibility, and/or good wall apposition, or may be braided from a plurality of filaments. The proximal portion may include one or more tapered portions that allow the device to be retrievable. The distal portion includes a flower portion or a plurality of ring assemblies each including rings of different sizes and flexibilities. The proximal portion is connected to the distal portion by an intermediate portion that may include a plurality of straight or elongation struts or a unit cell of the proximal portion. The intermediate portion and the distal portion may be shaped into an umbrella shape or a reverse umbrella shape. The delivery device for the stent includes an outer sheath (e.g., a microcatheter) containing the stent in the compressed delivery state and a plunger configured to push the stent out of the outer sheath and to release the stent mechanically, chemically, or electrolytically. The plunger may also include a guidewire lumen for aid in positioning of the delivery device at the treatment area or for maintaining access distally after delivery of the device.

During deployment, the distal portion expands from the compressed delivery state, possibly to an expanded state, to a further expanded state that is substantially planar compared to the dimensions of the proximal portion. In some embodiments, the distal section is changed to a further expanded state in a "blooming" action, wherein the distal end of the distal section moves outwardly and proximally, and the proximal end of the distal section moves inwardly and distally. In some embodiments, the distal section is changed to a further expanded state in a "blooming" action, wherein the proximal end of the distal section moves outwardly and distally, and the distal end of the distal section moves inwardly and proximally.

The proximal portion is positioned in an afferent vessel and the distal portion is positioned in a bifurcation junction across the neck of an aneurysm. In some embodiments, at least a portion of certain struts or rings of the distal portion may contact the fundus of the aneurysm and/or be placed inside the aneurysm. The intermediate portion does not interfere with blood flow to efferent vessels. Before or after the stent is in position, embolic material is used to treat the aneurysm using the stent delivery catheter or a different catheter. The distal portion is configured to act as a scaffolding to prevent herniation of objects out of the neck and/or fundus of the bifurcation aneurysm. The distal portion may be configured to allow insertion of embolic material therethrough. The device may also or alternatively be used to treat or inhibit ischemic stroke or other diseases by retrieving thrombi or blood clots. The device may also treat stroke by providing revascularization before or during thrombus retrieval. The proximal section can trap a clot and the distal section can provide distal embolic protection by catching stray clots and clot fragments.

According to some embodiments, an intraluminal device of the present discloses comprises a proximal section con-

figured to anchor in an afferent vessel; an intermediate section comprising a plurality of struts configured to allow perfusion to efferent vessels; and a distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm; wherein each of the plurality of struts is coupled at a coupling to the distal section at a region between a proximal end of the distal section and a distal end of the distal section; wherein the distal section is biased to transition from a first configuration forming a substantially cylindrical shape to a second configuration forming a substantially planar shape when released from a catheter.

According to some embodiments, the proximal section may comprise a hybrid cell design comprising open cells and closed cells. The proximal section may comprise a plurality of repeating unit cells. The distal section may comprise at least one said unit cell and at least partially forms a semi-sphere, umbrella, reverse umbrella, or flower shape in an expanded state.

According to some embodiments, the proximal section may comprise a plurality of woven filaments. The proximal section may comprise at least one tapered portion. The proximal section may have a length between about 5 mm and about 30 mm. The proximal section may have a length between about 10 mm and about 20 mm. The intermediate section may have a length between about 0 mm and about 6 mm.

According to some embodiments, the substantially cylindrical shape may have an inner surface and an outer surface, and each of the inner surface and the outer surface of the substantially cylindrical shape may define a respective opposing proximal and distal side of the substantially planar shape in the second configuration. The distal section may have a smallest inner cross-sectional dimension in the second configuration that is less than a smallest inner cross-sectional dimension of the proximal section.

According to some embodiments, while transitioning from the first configuration to the second configuration, (i) a distal portion of the distal section may be configured to move radially outwardly and proximally relative to the coupling and (ii) a proximal portion of the distal section may be configured to move radially inwardly and distally relative to the coupling. While transitioning from the first configuration to the second configuration, the distal portion may move to an axial location substantially aligned with or proximal to the coupling. While transitioning from the first configuration to the second configuration, the distal portion may move radially outwardly to define, in the second configuration, an outermost cross-sectional dimension that is greater than an outermost cross-sectional dimension of the proximal section. While transitioning from the first configuration to the second configuration, the proximal portion may move to an axial location substantially aligned with or distal to the coupling. While transitioning from the first configuration to the second configuration, the proximal portion may move radially inwardly to define, in the second configuration, an innermost cross-sectional dimension that is less than an innermost cross-sectional dimension of the proximal section.

According to some embodiments, when transitioned from the first configuration to the second configuration, the proximal portion of the distal section may define a first lumen sized smaller than a second lumen defined by the proximal section.

According to some embodiments, the distal section may pivot about the coupling when transitioning from the first configuration to the second configuration.

According to some embodiments, while transitioning from the first configuration to the second configuration, (i) a distal portion of the distal section may be configured to move radially inwardly and proximally relative to the coupling and (ii) a proximal portion of the distal section may be configured to move radially outwardly and distally relative to the coupling. While transitioning from the first configuration to the second configuration, the proximal portion may move radially outwardly to define, in the second configuration, an outermost cross-sectional dimension that is greater than an outermost cross-sectional dimension of the proximal section. While transitioning from the first configuration to the second configuration, the distal portion may move radially inwardly to define, in the second configuration, an innermost cross-sectional dimension that is less than an innermost cross-sectional dimension of the proximal section.

According to some embodiments, the distal section may comprise a plurality of woven filaments. The proximal section and the distal section are integrally cut from a tube or a sheet. The proximal section and the distal section are comprised of the same material. The distal section may comprise a covering.

According to some embodiments, an intraluminal device of the present discloses includes a proximal section configured to anchor in an afferent vessel; an intermediate section configured to allow perfusion to efferent vessels; and a distal section comprising a first plurality of rings and a second plurality of rings; wherein the distal section is configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm; wherein the distal section is biased to transition from a first configuration to a second configuration when released from a sheath; wherein, while in the first configuration, the first plurality of rings and the second plurality of rings extend parallel to a longitudinal axis of the intraluminal device; and wherein, while in the second configuration, the first plurality of rings extend radially inwardly and the second plurality of rings extend radially outwardly.

According to some embodiments, the first plurality of rings may be more flexible than the second plurality of rings. Each of the first plurality of rings may have a largest dimension smaller than a diameter of the proximal portion and each of the second plurality of rings may have a largest dimension larger than a diameter of the proximal portion. The first and second plurality of ring assemblies each may comprise between about 1 and about 30 rings.

According to some embodiments, a method of manufacturing an intraluminal device, comprises: coupling a proximal section to a distal section by an intermediate section, the proximal section configured to anchor in an afferent vessel, the intermediate section configured to allow perfusion to efferent vessels, and the distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm.

According to some embodiments, the method of manufacturing may further comprise cutting the proximal section from a sheet or a tube. Cutting the proximal section may comprise cutting a hybrid cell design. According to some embodiments, the method of manufacturing may further comprise cutting the distal section from a sheet or a tube. Cutting the distal section may comprise cutting a flower portion. Cutting the distal section may comprise cutting a plurality of rings. According to some embodiments, the method of manufacturing may further comprise cutting the intermediate section from a sheet or a tube.

According to some embodiments, coupling the proximal section to the distal section by the intermediate section may comprise integrally forming the proximal section, the distal section, and the intermediate section.

According to some embodiments, the method of manufacturing may further comprise weaving the proximal section from a plurality of filaments. According to some embodiments, the method of manufacturing may further comprise weaving the distal section from a plurality of filaments.

According to some embodiments, coupling the proximal section to the distal section by the intermediate section may comprise welding the proximal section to the intermediate section. Coupling the proximal section to the distal section by the intermediate section may comprise welding the distal section to the intermediate section.

According to some embodiments, the method of manufacturing may further comprise heat setting the proximal section to have an expanded state. According to some embodiments, the method of manufacturing may further comprise heat setting the distal section to have a further expanded state.

According to some embodiments, a method of treating an aneurysm at a junction of a bifurcation having an afferent vessel and efferent vessels, the aneurysm having a neck and a fundus, comprises: advancing a catheter proximate to the junction of the bifurcation, the catheter at least partially containing a device in a compressed state, the device comprising: a proximal section configured to anchor in an afferent vessel; an intermediate section configured to allow perfusion to efferent vessels; and a distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm; expanding the distal section from the compressed state to a radially expanded state at the junction of the bifurcation, wherein a distal end of the distal section may move radially outwardly and proximally relative to the proximal section, and a proximal end of the distal section may move radially inwardly and distally relative to the proximal section.

According to some embodiments, the method of treating may further comprise expanding the proximal section within an afferent vessel proximal to the bifurcation after expanding the distal section.

According to some embodiments, the method of treating may further comprise inserting embolic material into the aneurysm. Inserting the embolic material may comprise inserting the embolic material from the catheter. Inserting the embolic material may comprise inserting the material through a lumen defined by the expanded distal section.

Inserting the embolic material is before expanding the distal section. Inserting the embolic material is after expanding the distal section. Inserting the embolic material is during expanding the distal section. Inserting the embolic material may comprise inserting embolic coils. Inserting the embolic material may comprise inserting embolic fluid.

According to some embodiments, the method of treating may further comprise retrieving the distal section at least partially back into the catheter, and redeploying the distal section.

According to some embodiments, expanding the distal section may comprise releasing the device from the catheter. Releasing the device from the catheter may comprise mechanical detachment. Releasing the device from the catheter may comprise electrolytic detachment. According to some embodiments, the aneurysm may comprise a basilar tip aneurysm.

According to some embodiments, the intermediate section may comprise a plurality of struts and each of the plurality of struts may comprise a distal portion coupled, at a coupling, to the distal section at a region between a proximal end of the distal section and a distal end of the distal section.

According to some embodiments, a method of retrieving a clot from a vessel comprises advancing a catheter in the vessel distal to the clot, the catheter at least partially containing a device in a compressed state, the device including a proximal section and a distal section; deploying the device from at least partially inside the catheter to outside the catheter, wherein, during deployment, the proximal section self-expands alongside the clot and engages the clot; and the distal section self-expands to a further expanded state and is configured to catch stray clots or stray clot fragments, wherein the distal section has a second diameter in the further expanded state, the second diameter larger than the first diameter, wherein the distal end of the distal section moves outwardly and proximally, and the proximal end of the distal section moves inwardly and distally; or the proximal end of the distal section moves outwardly and distally, and the distal end of the distal section moves inwardly and proximally; retrieving the device and the clot (e.g., at least partially back into the catheter or another retrieval device); and removing the catheter from the vessel.

According to some embodiments, the vessel may have an inner diameter and the second diameter is the same as the inner diameter of the vessel. The proximal section may comprise a tapered portion. The proximal section may comprise a plurality of tapered portions. The proximal section may comprise a longitudinal slit at least partially defining edges and the edges overlap to form a coiled configuration.

According to some embodiments, during deployment, the edges may spring open to engage the clot. During retrieval, the edges may clamp down on the clot. The proximal section may comprise a hybrid cell design. The distal section may comprise a flower portion. The distal section may comprise a plurality of rings. The distal section may comprise a semi-sphere, umbrella, or reverse umbrella shape.

According to some embodiments, an intraluminal device comprises: a plurality of forward peaks, wherein at least some of the forward peaks are forward free-peaks; a plurality of reverse peaks; and a strut connected proximate to a tip of each said reverse peak.

According to some embodiments, at least some of the struts may be substantially straight. At least some of the struts may be s-shaped or c-shaped. At least some of the struts may be connected to a tip of at least some of said reverse peaks. At least some of the struts may be connected offset from a tip of at least some of said reverse peaks. A group of forward peaks and reverse peaks may form a unit cell and the device may comprise a plurality of connected unit cells repeating longitudinally along the device.

The intraluminal device may further comprise a tapered portion. The intraluminal device may further comprise a plurality of tapered portions.

According to some embodiments, a method of treating an aneurysm at a junction of a bifurcation having an afferent vessel and efferent vessels comprises advancing a catheter proximate to the junction of the bifurcation, the catheter at least partially containing a device in a compressed state, the device comprising: a proximal section configured to anchor in an afferent vessel; an intermediate section comprising a plurality of struts configured to allow perfusion to efferent vessels; and a distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation

aneurysm; wherein each of the plurality of struts comprises a distal portion coupled, at a joint, to the distal section at a region of the distal section between a proximal end of the distal section and a distal end of the distal section; expanding the distal section from the catheter at the junction of the bifurcation, wherein each of the proximal end and the distal end may pivot about the joint, such that the distal section at least partially everts.

For purposes of summarizing the subject technology and the advantages that may be achieved over the prior art, certain objects and advantages of the subject technology are described herein. Of course, it is to be understood that not necessarily all such objects or advantages need to be achieved in accordance with any particular embodiment. Thus, for example, those skilled in the art will recognize that the subject technology may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught or suggested herein without necessarily achieving other objects or advantages as may be taught or suggested herein.

All of these embodiments are intended to be within the scope of the subject technology herein disclosed. These and other embodiments will become readily apparent to those skilled in the art from the following detailed description having reference to the attached figures, the subject technology not being limited to any particular disclosed embodiment(s).

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the subject technology are described with reference to the drawings of certain embodiments, which are intended to illustrate certain embodiments and not to limit the subject technology.

FIG. **1** illustrates an example embodiment of a side wall aneurysm.

FIG. **2** illustrates an example embodiment of a bifurcation having an aneurysm.

FIG. **3**A illustrates an example embodiment of a side wall aneurysm with herniating embolization coils.

FIG. **3**B illustrates an example embodiment of a bifurcation having an aneurysm with herniating embolization coils.

FIG. **4**A illustrates an example embodiment of a side wall aneurysm treated with embolization coils and a tubular remodeling device.

FIG. **4**B and FIG. **4**C illustrates example embodiments of a bifurcation having an aneurysm treated with embolization coils and tubular remodeling devices.

FIG. **5**A is a side elevational view of an example embodiment of a vascular remodeling device.

FIGS. **5**B, **5**C, and **5**D are front elevational views of example embodiments of distal sections of the vascular remodeling device of FIG. **5**A.

FIGS. **6**A, **6**B, **6**C, and **6**D illustrate an example embodiment of further expansion of the distal section of the vascular remodeling device of FIG. **5**A.

FIG. **7**A and FIG. **7**B illustrate an example embodiment of a method for treating an aneurysm using the device of FIG. **5**A.

FIGS. **8**A, **8**B, and **8**C illustrate example embodiments of vascular remodeling device detachment mechanisms.

FIG. **9**A illustrates an example embodiment of a cut patterns in a hypotube for forming the device of FIG. **5**A.

FIG. **9**B illustrates the cut pattern of FIG. **9**A rotated 90°.

FIG. **10**A illustrates a perspective view of another example embodiment of a vascular remodeling device.

FIG. **10**B illustrates a front elevational view of the device of FIG. **10**A.

FIG. **10**C illustrates an example embodiment of a cut pattern in a sheet or a hypotube for forming the device of FIG. **10**A.

FIG. **11** illustrates an example embodiment of a treated aneurysm using the device of FIG. **10**A.

FIGS. **12**A, **12**B, **12**C, **12**D, **12**E, **12**F, **12**G, **12**H, **12**I, and **12**J illustrate example embodiments of proximal sections of vascular remodeling devices.

FIG. **13**A and FIG. **13**B illustrate example embodiments of intermediate sections of vascular remodeling devices.

FIGS. **14**A, **14**B, **14**C, **14**D, **14**E, and **14**F illustrate example embodiments of distal sections of vascular remodeling devices.

FIG. **15** illustrates an example embodiment of a distal section of a vascular remodeling device.

FIG. **16** illustrates a side-back perspective view of another example embodiment of a vascular remodeling device.

FIG. **17** illustrates a side elevational view of another example embodiment of a vascular remodeling device.

FIGS. **18**A, **18**B, **18**C, **18**D, and **18**E illustrate an example embodiment of a method for treating an aneurysm using a vascular remodeling device.

FIGS. **19**A, **19**B, **19**C, **19**D, and **19**E illustrate another example embodiment of a method for treating an aneurysm using a vascular remodeling device.

FIGS. **20**A, **20**B, and **20**C illustrate another example embodiment of a method for treating an aneurysm using a vascular remodeling device.

FIGS. **21**A, **21**B, and **21**C illustrate example embodiments of a method for clot retrieval using a vascular remodeling device.

FIGS. **22**A, **22**B, and **22**C illustrate example embodiments of proximal sections of a vascular remodeling device.

FIG. **23** illustrates another example embodiment of a vascular remodeling device.

DETAILED DESCRIPTION

Although some embodiments and examples are described below, those of skill in the art will appreciate that the subject technology extends beyond the specifically disclosed embodiments and/or uses and obvious modifications and equivalents thereof. Thus, it is intended that the scope of the subject technology disclosed herein should not be limited by any particular embodiments described below.

The use of numerical values in the various ranges specified in this application, unless expressly indicated otherwise, are stated as approximations as though the minimum and maximum values within the stated ranges were both preceded by the word "about." Slight variations above and below the stated ranges may be used to achieve substantially the same results as values within the ranges. The disclosure of ranges is intended as a continuous range including every value between the minimum and maximum values recited as well as any ranges that can be formed by such values. Accordingly, the skilled person will appreciate that many such ratios, ranges, and ranges of ratios can be unambiguously derived from the data and numbers presented herein and all represent various embodiments of the subject technology.

FIG. **5**A illustrates an example embodiment of a vascular remodeling device **50** comprising a scaffolding distal section **56**. It will be appreciated that the device **50** may be more compliant than the vasculature in which it is deployed such that it may be somewhat misshapen after being deployed,

and that certain shapes described herein are when the device **50** is an expanded (e.g., further expanded) state with no restriction. The device **50** comprises a proximal section **52** (or "bottom section" or "main body" or "stem" or "tubular portion" or "anchoring section"), an intermediate section **54** (or "middle section" or "open portion" or "flow section"), and a distal section **56** (or "top section" or "distal portion" or "flower" or "flower portion" or "umbrella section" or "treatment section"). The device **50** can be delivered via a catheter (e.g., microcatheter, guide catheter, delivery catheter) into a bifurcation to support an aneurysm filling device with minimal interruption of blood flow in afferent and efferent vessels. In some embodiments, the device **50** may be retrieved and/or repositioned.

The intermediate section **54** comprises a plurality of struts **55**. The struts **55** may be straight, curved, or otherwise shaped, such as having design features like the proximal section **52** with the same or a different cell size. The struts **55** couple the proximal section **52** to the distal section **56**. In some embodiments, each of the struts **55** contains at least two terminals ends. The terminal ends may connect to each of the proximal section **52** and the distal section **56**. According to some embodiments, the distal section **56** contains a proximal portion (e.g., proximal end or proximal terminal end) and a distal portion (e.g., distal end or distal terminal end). A distal portion (e.g., distal end, or terminal distal end) of each of the struts **55** may couple to or join with the distal section **56** at a connection point, coupling location, or joint between the proximal end of the distal section **56** and the distal end of the distal section **56**, as shown in FIG. **6**A. The coupling location forms a joint about which at least some portions of distal section **56** may pivot. In some embodiments, at least some of the struts **55** connect with a distal portion thereof at a middle portion of the distal section **56**. In some embodiments, at least some of the struts **55** connect with a distal portion thereof at the proximal end of the distal section **56**. In some embodiments, at least some of the struts **55** connect with a distal portion thereof at the distal end of the distal section **56**. In some embodiments, the struts **55** have a substantially rectangular or flat cross section (e.g., embodiments, in which the struts **55** comprise ribbons or uncut portions of a metallic tube or sheet). In some embodiments, the struts **55** have a substantially round (e.g., circular, elliptical, ovoid) cross section (e.g., embodiments, in which the struts **55** comprise round filaments). In some embodiments, the plurality of struts **55** comprises two struts **55**. In some embodiments, the plurality of struts **55** comprises greater than two struts **55**. In some embodiments, the plurality of struts **55** comprises between about two struts **55** and about twelve struts **55** (e.g., between about three struts **55** and about eight struts **55**, three struts **55**, four struts **55**, five struts **55**, six struts **55**, seven struts **55**, or eight struts **55**). Other numbers of struts are also possible. In certain embodiments, the struts **55** may be equally spaced and/or oriented on opposite sides of the device **50** (e.g., two struts 180° apart along the circumference of the device **50**, three struts 120° apart along the circumference of the device **50**, four struts 90° apart along the circumference of the device **50**, etc.). When the device **50** is placed at a bifurcation, the intermediate section **54** allows perfusion of blood to efferent vessels because the struts **55** do not block fluid flow.

In some embodiments, the proximal section **52** has a first diameter and the distal section **56** has a second diameter greater than the first diameter (e.g., due to the further expansion), which may cause the struts **55** to be angled or curved outwards from the longitudinal axis defined by the proximal section **52**. In certain embodiments, the proximal section **52** has a round (e.g., circular, elliptical, or ovoid) cross section. In some embodiments, the proximal section **52** includes filaments having a substantially rectangular or flat cross section (e.g., embodiments, in which the proximal section **52** comprises ribbons or uncut portions of a metallic tube or sheet). In some embodiments, the proximal section **52** includes filaments having a substantially round (e.g., circular, elliptical, ovoid) cross section (e.g., embodiments, in which the proximal section **52** comprises round filaments). In some embodiments, the proximal section **52** comprises a plurality of z-shaped segments coupled by struts (e.g., as illustrated in FIG. **5**A). Other patterns of the proximal section **52** are also possible, for example as described with respect to FIGS. **12**A-**12**J. When the device **50** is placed at a bifurcation, the proximal section **52** provides anchoring of the device **50** in the afferent vessel. The proximal section **52** may also facilitate delivery, positioning, retrieval, and/or repositioning of the device **50**.

In the example embodiment illustrated in FIG. **5**A, the proximal end of the proximal section **52** comprises two tapered portions **53**. The tapered portions **53** may allow the device **50** or portions thereof (e.g., the proximal section **52**) to be retrieved back into a catheter. For example, if the device **50** is being pulled into a catheter, the tapered portions **53** may radially compress the proximal section **52**. One tapered portion **53** or other numbers of tapered portion **53** are also possible.

FIGS. **5**B-**5**D illustrate example embodiments of the distal section **56** in a further expanded state. The distal section **56** allows for safe and controlled placement of coils, and can be designed to support a certain packing density of coil. Upon deployment, the distal section **56** can be placed at the neck of an aneurysm and can cover the neck enough that aneurysm filling devices can still be positioned inside the aneurysm. In some embodiments, the distal section **56** comprises one or more of a mesh, a covering, additional filaments, etc. to achieve a fluid diversion effect, which may allow the omission of embolic material or an aneurysm filling device. FIG. **5**C illustrates the distal section **56** of FIG. **5**B with radiopaque markers (e.g., coils) around certain filaments. FIG. **5**D illustrates the distal section **56** with fewer filaments than FIG. **5**B.

In some embodiments, the device **50** comprises a self-expanding (e.g., super elastic, CoCr alloy, polyglycolic acid, polylactic acid, etc.) and/or a shape-memory material (e.g., Nitinol, shape memory polymers, etc.), thereby causing the device **50** to be self-expanding under certain conditions (e.g., not restrained by a catheter). In some embodiments, the proximal section **52**, the intermediate section **54**, and/or the distal section **56** may comprise different materials. For example, the distal section **56** may comprise polymer material while the proximal section **52** and the intermediate section **54** comprise metallic material, different polymer material, etc. For another example, the distal section **56** may comprise metallic material while the proximal section **52** and the intermediate section **54** comprise different metallic materials, polymer material, etc. Other combinations of materials are also possible. The device **50** can assume a low profile compressed state (e.g., confined within a catheter) for delivery. Upon deployment from the catheter, the device **50** expands (e.g., self-expands) from the compressed state to an expanded state. The distal section **56** expands (e.g., self-expands) to a further expanded state.

FIGS. **6**A-**6**D illustrate an example embodiment of further expansion of the distal section **56** of the device **50**. FIG. **6**A illustrates the device **50** in the expanded state (e.g., having been released from a catheter). The distal section **56***a* in the

expanded state has substantially the same diameter as the proximal section **52**. FIG. **6**B illustrates the distal section **56***b* in an intermediate further expanded state in which portions of the distal section **56***b* begin to assume a non-tubular shape, for example due to shape-setting of the distal section **56**. FIG. **6**C illustrates the distal section **56***c* in another intermediate further expanded state in which the portions of the distal section **56***c* further assume a non-tubular shape. FIG. **6**D illustrates the distal section **56***d* in the further expanded state. FIG. **6**D is a front perspective view of the device **50** of FIG. **5**A. In the intermediate further expanded states and the further expanded state illustrated in FIG. **5**A and FIGS. **6**B-**6**D, the distal section **56**, **56***b*, **56***c*, **56***d* has a larger diameter than the proximal section **52**. As illustrated in FIG. **5**A, in the further expanded state, the distal section **56** may be substantially flat (e.g., flat) or substantially planar (e.g., planar). In some embodiments, the distal section **56** changes or is biased to change to a further expanded state in a "blooming" action, wherein the distal portion of the distal section **56** moves radially outwardly and proximally relative to the coupling of the struts **55** to the distal section **56**, and the proximal portion of the distal section **56** moves radially inwardly and distally relative to the coupling of the struts **55** to the distal section **56**. In some embodiments, the distal section **56** is changed or is biased to change to a further expanded state in a "blooming" action, wherein the proximal end of the distal section **56** moves radially outwardly and distally relative to the coupling of the struts **55** to the distal section **56**, and the distal portion of the distal section **56** moves radially inwardly and proximally relative to the coupling of the struts **55** to the distal section **56**. It will be appreciated that such actions of distal section **56** or portions thereof may be performed relative to (a) the coupling of the struts **55** to the distal section **56**, (b) the proximal section **52**, (c) the struts **55**, (d) the vessel, (e) the aneurysm, (f) a longitudinal axis of the device **50**, or (g) any other object or location. It will be appreciated that the device **50** may not expand from the compressed state to the expanded state to the further expanded state, but that the proximal section **52** may expand from the compressed state to the expanded state while the distal section **56** may expand from the compressed state to the further expanded state (e.g., without the distal section **56** expanding from the compressed state to the expanded state). If the device **50** is deployed from a catheter, the distal section **56** may expand from the compressed state to the further expanded state, possibly via the expanded state, after being released from the catheter while the proximal section **52** still remains in the compressed state within the catheter.

According to some embodiments, as shown in FIGS. **6**A-**6**D, the distal section **56** at least partially everts or is biased to evert at least partially during deployment. As used herein, "evert" and "eversion" refer to a process in which a structure turns inside-out. For example, a structure having a first surface initially facing inward and a second surface surface initially facing outward transitions during eversion such that at least one of the first surface ultimately faces outward and the second surface ultimately faces inward. Eversion may be complete or partial. Partial eversion refers to a process in which the structure begins, but does not necessarily complete, the transition described above. According to some embodiments, a length is defined between (i) each of the connection points at which the terminal ends of struts **55** are coupled to the distal section **56** and (ii) the proximal end of distal section **56**. According to some embodiments, a length is defined between (i) each of the connection points at which the terminal ends of struts **55** are coupled to the distal section **56** and (ii) the distal end of distal section **56**. According to some embodiments, each of the proximal end and the distal end may pivot about the connection points. According to some embodiments, each of the proximal end and the distal end may pivot about a section between the distal end and the proximal end, as shown in FIGS. **6**A-**6**D.

According to some embodiments, the distal section **56** forms a substantially cylindrical (e.g., cylindrical) shape in a first, compressed state, as shown in FIG. **6**A. The substantially cylindrical shape may define an inner surface facing radially inward and an outer surface facing radially outward. According to some embodiments, during or after deployment, the distal section **56** forms or is biased to form a substantially planar (e.g., planar) shape in a second, expanded state, as shown in FIG. **6**D. The distal end and the proximal end of distal section **56** are substantially coplanar (e.g., coplanar) in the second, expanded state. For example, either one of the distal end and the proximal end may become concentric within the other. In the concentric configuration, the distal end and the proximal end may form inner and outer bands having different cross-sectional dimensions. According to some embodiments, after deployment, the inner surface and the outer surface of the substantially cylindrical shape define opposing sides of the substantially planar shape. For example, the inner surface of the substantially cylindrical shape may transition to a proximal side of the substantially planar shape, and the outer surface of the substantially cylindrical shape may transition to a distal side of the substantially planar shape. By further example, the inner surface of the substantially cylindrical shape may transition to a distal side of the substantially planar shape, and the outer surface of the substantially cylindrical shape may transition to a proximal side of the substantially planar shape.

In some embodiments, the device **50** comprises a radiopaque material such as platinum, platinum-iridium, and/or tantalum (e.g., being at least partially formed from the radiopaque material (e.g., having a radiopaque layer, consisting of a radiopaque material), including radiopaque markers). For example, the struts **55** may comprise radiopaque markers. For another example, certain segments of the distal section **56** may comprise radiopaque markers in the form of marker coils and/or marker bands (e.g., as illustrated in FIG. **5**C). For yet another example, the struts **55** and certain segments of the distal section **56** may comprise radiopaque markers. For another example, structural struts in the distal section **56** can themselves comprise (e.g., be made from) a radiopaque material. For still another example, certain segments of the proximal section **52** (e.g., the tapered portions **53**, tips of peaks) may comprise radiopaque markers. For another example, structural struts in the proximal section **52** can themselves comprise (e.g., be made from) a radiopaque material. It will be appreciated that the amount and type of radiopaque material used may depend, inter alia, on process technologies, desired level of radiopacity, mechanical properties of the radiopaque material, and corrosion properties of the radiopaque material.

In some embodiments, the device **50** is configured to be positioned at a junction of a bifurcation (e.g., a neurovascular bifurcation (e.g., the basilar tip area)) comprising at least one afferent vessel, efferent vessels, and an aneurysm having a fundus and a neck. For example, in some embodiments, the proximal section **52** is suitably dimensioned to fit in an afferent vessel of a bifurcation (e.g., having a diameter between about 2 mm and about 12 mm, having a diameter between about 6 mm and about 8 mm, having a diameter less

than about 15 mm, having a diameter greater than about 1 mm). For example, in some embodiments, the proximal section **52** is suitably dimensioned to fit in an afferent vessel of a bifurcation. In certain embodiments, the device **50** is configured to act as a scaffolding to inhibit or prevent herniation or prolapse of objects (e.g., embolization coils, thrombi, etc.) out of a neck of an aneurysm. As used herein, "herniation" refers to relocation of coils from an implanted location (e.g., within an aneurysm) to a location other than the implanted location (e.g., outside an aneurysm). Herniation may or may not be caused by an external force acting on the coils. For another example, in some embodiments, the distal section **56** is dense enough that such objects cannot pass. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is between about 3% and about 25%. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is between about 3% and about 15%. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is at least about 5%. For another example, in some embodiments, the distal section **56** allows insertion of embolic material therethrough (e.g., through apertures or spaces between struts or filaments). In certain embodiments, the device **50** is configured to permit perfusion of fluid (e.g., blood) to efferent vessels of a bifurcation. For yet another example, in some embodiments, the intermediate section **54** is substantially devoid of a covering, mesh, or other material between the struts **55**, thereby allowing fluid to flow substantially unimpeded.

FIG. **7**A and FIG. **7**B illustrate an example embodiment of a method for treating an aneurysm **20** using the device **50** at a confluence of afferent and efferent vessels or "junction" at a bifurcation **60** having an aneurysm **20**. In some embodiments, the vessels are neurovascular or cranial. For example, the vasculature may include the basilar tip aneurysm, the middle cerebral artery, the anterior communicating artery, or the internal carotid bifurcation. In the case of a basilar tip aneurysm, which is at a junction in which the efferent vessels are at about a 90° angle to the afferent vessel, deployment of a conventional aneurysm-bridging stent between the efferent vessels and proximal to the aneurysm neck such that the device can hold embolic material in the aneurysm fundus may be difficult. Treatment of other vasculature, including other than neurovascular or cranial, is also possible.

FIG. **7**A shows the proximal section **52** anchored in the afferent vessel and the distal section **56** placed across the neck of the aneurysm **20** after being deployed from a catheter (e.g., by being pushed out with a plunger, by retracting the catheter while the device remains stationary, etc.) and expanding as described herein. In some embodiments, the device **50** comprises a self-expanding and/or a shape-memory material that automatically expands (e.g., self-expands) towards an uncompressed state or does so upon the application of warm fluid (e.g., saline). The struts **55** of the intermediate section **54** allow fluid flow to the efferent vessels. FIG. **7**B illustrates a plurality of embolization coils **62** inserted in the fundus of the aneurysm **20**. It will be appreciated that the embolization coils **62** may be a single embolization coil or other embolic material (e.g., embolic fluid such as Onyx®, available from ev3). The embolization coils **62** or other embolic material may be inserted into the fundus before or after positioning of the device **50**. In some embodiments, the embolization coils **62** are inserted in the fundus of the aneurysm **20** using the same catheter from which the device **50** is deployed. In some embodiments, the embolization coils **62** are inserted in the fundus of the aneurysm **20** using a different catheter than the catheter from which the device **50** is deployed. In certain such embodiments, a guidewire may be used to guide both catheters. The device **50** acts as a scaffolding to inhibit or prevent herniation or prolapse of objects such as the embolization coils **62** and/or thrombi out of the aneurysm **20**. The distal section **56** of the device **50** may allow insertion of embolic material therethrough. The device **50** also allows perfusion of fluid (e.g., blood) from the afferent vessel(s) to the efferent vessel(s). If the position of the device **50** is not ideal, it can be pulled back inside the delivery catheters, repositioned, and redeployed at a different (e.g., better) position.

In some embodiments, final release of the device **50** is mechanical (e.g., by a release mechanism). In some embodiments, release of the device **50** is electrolytic (e.g., by applying a small current until a proximal tip of the tapered portions **53** corrodes away). In some embodiments, final release of the device **50** is chemical (e.g., by dissolving a connecting portion with a biocompatible solvent such as DMSO). The delivery systems and catheter may then be withdrawn from the bifurcation **60**, thereby leaving or permanently positioning the device **50** at the junction of the bifurcation **60**.

FIGS. **8**A-**8**C illustrate example embodiments of release mechanisms that may be used to decouple the device **50** from a pusher wire or other portion of a delivery catheter. These and other release mechanisms may also be used for other devices described herein. In some embodiments, the release mechanism comprises a corrodible wire (e.g., for electrolytic detachment). In some embodiments, the release mechanism comprises a chemically reactive substance (e.g., dissolvable by DMSO). In some embodiments, the release mechanism comprises a mechanical release mechanism.

FIG. **8**A illustrates a release mechanism **80** comprising a guidewire or catheter portion comprising an expanded end portion **81** (having a larger diameter than the portion proximal thereto) and a device proximal end portion comprising a plurality of fingers **82**. When the device is confined within a catheter, the compression of the device material causes the fingers **82** to lock around the expanded end portion **81** and to couple the device proximal end portion to the guidewire or catheter portion. The device may optionally be released by causing the device proximal end to exit the catheter (e.g., by pushing a guidewire and/or pulling a catheter), at which point the fingers **82** may flex outwardly and lose grip on the expanded portion **81** (e.g., as illustrated in FIG. **8**B). Alternatively, the device proximal end portion may comprise the expanded portion **81** and the guidewire or catheter portion may comprise the plurality of fingers **82**.

FIG. **8**C illustrates an example embodiment of an electrolytic release mechanism **85** comprising interlocking pieces **86**, **87**. A guidewire or a catheter portion comprises the piece **86** and the device proximal end portion comprises the piece **87**, although a reverse configuration and other piece shapes are also possible. Unlike the expanded end portion **81** and the fingers **82** of the embodiment of FIG. **8**A and FIG. **8**B, the interlocking pieces **86**, **87** are not configured to be released from each other. Although illustrated as proximal to the pieces **86**, **87**, a marker band **89** may surround the pieces **86**, **87**. The device may optionally be released by applying an electrical current and causing a narrow portion **88** of the device (e.g., proximal (e.g., immediately proximal) to the "bumper" or "glue dome") to dissolve, thereby releasing the distal end portion of the

guidewire or the catheter portion and the device. In embodiments comprising a marker band **89**, the marker band **89** may also be released from the guidewire or catheter portion and remain with the device by being distal to the narrow portion **88**.

It will be appreciated that the term "permanently" does not mean that the device **50** is impossible to remove and/or reposition a later time. In some embodiments, the delivery catheter or a different catheter may be used to retrieve or reposition the device **50**. In certain embodiments, the device **50** may be retracted into a catheter after being deployed. The device **50** may then be repositioned, for example, at a new rotational position, more proximal or distal to an afferent vessel and/or an efferent vessel, etc, or may be completely removed from the body, for example prior to delivery of a new device (e.g., a different device **50**). Once the user is satisfied with the repositioned properties of the device **50** (e.g., size, position, rotation, shape, interaction with the vessels, etc.), the device **50** may be released.

FIG. **9**A and FIG. **9**B illustrate an example embodiment of a vascular remodeling device **50** at a stage of an example manufacturing process comprising cutting and shaping a metallic tube (e.g., a laser cut hypotube), FIG. **9**B being rotated 90° with respect to FIG. **9**A. Other tube diameters are also possible. A laser may cut out portions of the tube, leaving a plurality of filaments in the proximal section **52**, struts **55** in the intermediate section **54**, and a plurality of filaments in the distal section **56**. Other cutting methods (e.g., chemical etch, mechanical cutting, etc.) are also possible.

FIG. **10**A illustrates an example embodiment of a vascular remodeling device **100** comprising a scaffolding distal section **106**. It will be appreciated that the device **100** may be more compliant than the vasculature in which it is deployed such that it may be somewhat misshapen after being deployed, and that certain shapes described herein are when the device **100** is an expanded (e.g., further expanded) state with no restriction. The device **100** comprises a proximal section **102** (or "bottom section" or "main body" or "stem" or "tubular portion" or "anchoring section"), an intermediate section **104** (or "middle section" or "open portion" or "flow section"), and a distal section **106** (or "top section" or "distal portion" or "flower" or "flower portion" or "umbrella section" or "treatment section"). The device **100** can be delivered via a catheter (e.g., microcatheter) into a bifurcation to support an aneurysm filling device with minimal interruption of blood flow in afferent and efferent vessels. In some embodiments, the device **100** may be retrieved and/or repositioned if needed.

The intermediate section **104** couples the proximal section **102** to the distal section **106**. The intermediate section may comprise reduced material compared to the distal section **106** and/or the proximal section **102** to reduce interruption of fluid flow to efferent vessels and/or to reduce the risk of potential obstruction of efferent vessels. The intermediate section **104** comprises a plurality of struts **105**. The struts **105** may be straight, curved, or otherwise shaped, such as having design features like the proximal section **102** with the same or a different cell size. The struts **105** couple the proximal section **102** to the distal section **106**. In some embodiments, the struts **105** have a substantially rectangular or flat cross section (e.g., embodiments, in which the struts **105** comprise ribbons or uncut portions of a metallic tube or sheet). In some embodiments, the struts **105** have a substantially round (e.g., circular, elliptical, ovoid) cross section (e.g., embodiments, in which the struts **105** comprise round filaments). In some embodiments, the intermediate section **104** has a length between about 0 mm and about 6 mm. In embodiments in which the intermediate section **104** has a length of about 0 mm, the distal section **106** may be directly coupled to the proximal section **102**, and the proximal section **102** may comprises a pattern and/or porosity that allows perfusion to efferent vessels.

In certain embodiments, the struts **105** are integrally fabricated with the proximal section **102** and the distal section **106**, for example as described with respect to FIG. **10**C. In embodiments in which all sections **102**, **104**, **106** of the device **100** are integrally fabricated by being cut from the same tube or sheet, the device **100** is of single-piece construction. In certain embodiments, the struts **105** are made from a different piece and are attached (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.) to each of the proximal section **102** and the distal section **106**. Separately formed struts **105** allows the struts **105** to be a different material from the proximal section **102** and the distal section **106**, although it will be appreciated that flat pieces of metal may also comprise multiple sections comprising different metals. In some embodiments, the struts **105** comprise biocompatible metal and/or biocompatible polymer. In some embodiments, the struts **105** comprise radiopaque material (e.g., in the form of a radiopaque core, cladding, coating, small coiled wire, marker band, etc.), which can act as radiopaque markers for improved visibility of the device **100** during a procedure and/or following optional implantation.

In some embodiments, the plurality of struts **105** comprises two struts **105**. In some embodiments, the plurality of struts **105** comprises greater than two struts **105**. In some embodiments, the plurality of struts **105** comprises between about two struts **105** and about twelve struts **105** (e.g., between about three struts **105** and about eight struts **105**, three struts **105**, four struts **105**, five struts **105**, six struts **105**, seven struts **105**, or eight struts **105**). Other numbers of struts **105** are also possible. In some embodiments, the struts **105** may be equally spaced and/or oriented on opposite sides of the device **100** (e.g., two struts 180° apart along the circumference of the device **100**, three struts 120° apart along the circumference of the device **100**, four struts 90° apart along the circumference of the device **100**, etc.). In some embodiments, the number of struts **105** corresponds to the number of distal section ring assemblies described herein. When the device **100** is placed at a bifurcation, the intermediate section **104** allows perfusion of blood to efferent vessels because the struts **105** do not block fluid flow.

The proximal section **102** may be flexible and yet have enough radial force to anchor or maintain the position of the device **100** at a bifurcation after deployment (e.g., to inhibit or prevent longitudinal migration of the device **100**). In certain embodiments, the proximal section **102** has a first diameter and the distal section **106** has a second diameter greater than the first diameter (e.g., due to expansion of the distal section ring assemblies), which may cause the struts **105** to be angled or curved outwards from the longitudinal axis defined by the proximal section **102**. In certain embodiments, the proximal section **102** has a round (e.g., circular, elliptical, or ovoid) cross section. In some embodiments, the proximal section **102** includes filaments having a substantially rectangular or flat cross section (e.g., embodiments, in which the proximal section **102** comprises ribbons or uncut portions of a metallic tube or sheet). In some embodiments, the proximal section **102** includes filaments having a substantially round (e.g., circular, elliptical, ovoid) cross section (e.g., embodiments, in which the proximal section **102**

comprises round filaments). In some embodiments, the proximal section **102** comprises a combination open cell and closed cell design and coupling struts (e.g., as illustrated in FIG. **10**A), described in further detail herein. In certain such embodiments, the proximal section **102** may achieve good flexibility and/or have good vasculature conformance. In some embodiments, the proximal section **102** comprises a plurality of woven filaments.

When the device **100** is placed at a bifurcation, the proximal section **102** provides anchoring of the device **100** in the afferent vessel. The proximal section **102** may also facilitate delivery, positioning, retrieval, and/or repositioning of the device **100**. In some embodiments, the proximal end of the proximal section **102** comprises a detachment portion, for example a detachment mechanism described herein, for example with respect to FIGS. **8**A-**8**C.

In certain embodiments, the proximal section **102** is fully retrievable back into a catheter, which can allow repositioning of portions of the device **100**. In certain embodiments, the proximal section **102** and the intermediate section **104** are fully retrievable back into a catheter, which can allow repositioning of portions of the device **100**. In certain embodiments, the proximal section **102**, the intermediate section **104**, and the distal section **106** are fully retrievable back into a catheter, which can allow repositioning of portions (e.g., the entirety) of the device **100**.

FIG. **10**A illustrates an embodiment in which the proximal end of the proximal section **102** comprises two tapered portions **103**. The tapered portions **103** may allow the device **100** or portions thereof (e.g., the proximal section **102**) to be retrieved back into a catheter. For example, if the device **100** is being pulled into a catheter, the tapered portions **103** may radially compress the proximal section **102**.

The distal section **106** may perform a variety of functions, for example providing support to embolic material such as embolic coils and/or diversion of blood flow away from an aneurysm. The distal section **106** may be atraumatic (e.g., comprising flexible materials, atraumatic shapes, etc.) to inhibit damaging or rupturing aneurysms. The distal section **106** may be self-aligning to accommodate possible misalignment between the afferent vessel and the neck of the aneurysm. The distal section **106** or portions thereof (e.g., certain rings or other features described herein) may be self-conforming to irregular contours of the neck of the aneurysm.

FIG. **10**B illustrates an example embodiment of the distal section **106** in an expanded state. The distal section **106** allows for safe and controlled placement of coils, and can be designed to support a certain packing density of coil. Upon deployment, the distal section **106** can be placed at the neck (e.g., at least partially inside the fundus) of an aneurysm and can cover the neck to reduce the effective neck size enough that aneurysm filling devices can still be positioned inside the aneurysm. The distal section **106** comprises a plurality of ring assemblies. In some embodiments, each ring assembly comprises a first ring **107**, a second ring **108**, and a third ring **109**. The first ring **107** has a first stiffness, the second ring **108** has a second stiffness, and the third ring **109** has a third stiffness. In certain embodiments, the first stiffness of the first ring **107** is greater than the second stiffness of the second ring **108** and the third stiffness of the third ring **109** (e.g., to provide good support to embolic material). In certain embodiments, the third stiffness of the third ring **109** is less than the first stiffness of the first ring **107** and the second stiffness the second ring **108** (e.g., to provide good conformability and to be less traumatic to the aneurysm).

In certain embodiments, the rings **107**, **108**, **109** are integrated with the proximal section **102** (e.g., being cut from the same tube or sheet). In embodiments in which all sections **102**, **104**, **106** of the device **100** are integrally fabricated by being cut from the same tube or sheet, the device **100** is of single-piece construction. Single-piece construction may allow for easier manufacturing. In certain embodiments, the rings **107**, **108**, **109** are formed separately from the proximal portion **102** and are attached (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.). In certain such embodiments, the rings **107**, **108**, **109** may comprise different material than the proximal section **102**. For example, the rings **107**, **108**, **109** may comprise platinum, platinum-iridium, or a polymer and the proximal section **102** may comprise Nitinol or CoCr alloy. Other combinations of materials are also possible. Separate or multiple-piece construction may allow for independent selection of materials that are suited for the intended use. In certain embodiments, some of the rings **107**, **108**, **109** are integrated with the proximal section **102** (e.g., being cut from the same tube or sheet) and others of the rings **107**, **108**, **109** are formed separately from the proximal portion and are attached (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.). Combination construction may allow easier fabrication than purely multiple-piece construction and also some material selection advantages.

In some embodiments, the third ring **109** and/or the second ring **108** is/are configured to conform to the contours of the anatomy and/or to self-align to the anatomy in the case of misalignment between the distal end **106** of the device **100** and the aneurysm and/or in the case of offset (e.g., long length, short length) between the afferent vessel and the neck of the aneurysm. In certain embodiments, the second stiffness of the second ring **108** is less than the first stiffness of the first ring **107** and is greater than the third stiffness of the third ring **109**. Stiffness of the rings **107**, **108**, **109** may be influenced, for example, by having different dimensions and/or by different heat treatment processes (e.g., resistive and/or inductive heat treatment processes). In some embodiments, a largest dimension of the ring **107** is smaller than a diameter of the proximal end **102** of the device **100** in an expanded state. In some embodiments, a largest dimension of the ring **109** is larger than a diameter of the proximal end **102** of the device **100** in an expanded state. In some embodiments, the distal section **102** comprises between about 1 and about 30 rings. In some embodiments, each ring assembly of the distal section **102** comprises between about 1 and about 30 rings. In some embodiments, the distal section **106** comprises one or more of a mesh, a covering, additional filaments, etc. to achieve a fluid diversion effect, which may allow the omission of embolic material or an aneurysm filling device.

FIG. **10**C illustrates an example embodiment of a vascular remodeling device **100** at a stage of an example manufacturing process comprising cutting and shaping a metallic sheet. A laser or electrochemical etching may cut out portions of the sheet, leaving a plurality of unit cells in the proximal section **102**, struts **105** in the intermediate section **104**, and a plurality of rings in the distal section **106**. In the embodiment illustrated in FIG. **10**C, the proximal section **102**, the intermediate section **104**, and the distal section **106** are integrally formed from the metallic sheet and not cut away from each other. In some embodiments in which all sections **102**, **104**, **106** of the device **100** are integrally

fabricated by being cut from the same tube or sheet, the device **100** is of single-piece construction. The cut may be defined by features such as a thickness t of the filaments, effective length l_e of the proximal section **102**, tapered length l_t of the proximal section **102**, and the number of unit cells in the proximal section **102**. In some embodiments, the width w is between about 0.02 mm and about 0.2 mm. In some embodiments, the width w is between about 0.03 mm and about 0.1 mm. In some embodiments, the width w is about 0.05 mm. Other widths w are also possible. The width w of the filaments may be uniform throughout the device **100**, or may vary depending on location. For example, struts connecting unit cells may be thicker than struts within unit cells. In some embodiments, the length of a unit cell is between about 1 mm and about 7 mm. In some embodiments, the length of a unit cell is between about 2 mm and about 5 mm. Other unit cell lengths are also possible. The dimensions described herein, including for example dimensions described with respect to FIG. **9**A and FIG. **9**B, may be uniform throughout the proximal section **102** of the device **100**, or may vary depending on location (e.g., increasing from proximal to distal, decreasing from proximal to distal, combinations thereof, and the like). Dimensions may be selected, for example, to accommodate certain vasculature, for flexibility, for wall conformance, etc.

After cutting or chemical etching, the sheet may be reshaped (e.g., into a tube) and the device **100** may be heat treated to impart shape setting to at least the proximal section **102** and the distal section **106**. The shape setting process may include several steps comprising, for example, successively shapes using appropriate tooling to stretch and confine the cut sheet into a new shape during the heat treatment. At the end of the each heat treatment step, the cut sheet assumes the shape in which it was confined during the heat treatment process. After shape setting the device **100**, the distal section **106** may be reshaped and the device **100** may be further heat treated to impart further shape setting to at least the distal section **106**. For example, the rings **107**, **108**, **109** may be shape set to take the shape illustrated in FIG. **10**A and FIG. **10**B. According to some embodiments, while in a first, compressed state, each of a first plurality of rings (e.g., one or more of rings **107**, rings **108**, and rings **109**) and each of a second plurality of rings (e.g., one or more others of rings **107**, rings **108**, and rings **109**) extends parallel to a longitudinal axis of the device **50**, as shown in FIG. **10**C. According to some embodiments, while in the second, expanded state, each of the first plurality of rings extends or is biased to extend radially inwardly and each of the second plurality of rings extends or is biased to extend radially outwardly, as shown in FIG. **10**A and FIG. **10**B. According to some embodiments, while in the second, expanded state, each of the first plurality of rings extends or is biased to extend radially outwardly, and each of the second plurality of rings extends or is biased to extend radially inwardly. According to some embodiments, the first plurality of rings may be any of rings **107**, **108**, **109**. According to some embodiments, the second plurality of rings may be any of rings **107**, **108**, **109**. As shown in FIG. **11**, a bias, as described herein, may allow one or more rings to be disposed against an inner surface of an aneurysm **110**.

The final shape (e.g., further expanded state) and size may obtained by several such steps. For the final shape, there may be a slit along the length of the device **100** (e.g., the opposite sides of the sheet are not joined), or the edge(s) can be welded or otherwise joined together by other methods to form a complete tubular profile. Devices described herein may also be formed using cut a metallic tube that is reshaped after being cut, although it will be appreciated that the properties of the initial tube and the pattern of the cut may be different.

In some embodiments, the device **100** comprises a self-expanding (e.g., super elastic, CoCr alloy, such as polyglycolic acid and polylactic acid, etc.) and/or a shape-memory material (e.g., comprising Nitinol, shape memory polymers, etc.), thereby causing the device **100** to be self-expanding under certain conditions (e.g., not restrained by a catheter). In some embodiments, the proximal section **102**, the intermediate section **104**, and/or the distal section **106** may comprise different materials (e.g., in addition to having different thicknesses as described herein). The device **100** can assume a low profile compressed state (e.g., confined within a catheter) for delivery. Upon deployment from the catheter, the device **100** expands (e.g., self-expands) from the compressed state to an expanded state. The distal section **106** expands (e.g., self-expands) to a further expanded state.

In some embodiments, the device **100** comprises a radiopaque material such as platinum, platinum-iridium, and/or tantalum (e.g., being at least partially formed from the radiopaque material (e.g., having a radiopaque layer, consisting of a radiopaque material), including radiopaque markers). For example, the struts **105** may comprise radiopaque markers. For another example, certain segments of the distal section **106** may comprise radiopaque markers and/or be made from radiopaque materials. For yet another example, the struts **105** and certain segments of the distal section **106** may comprise radiopaque markers. For still another example, certain segments of the proximal section **104** may comprise radiopaque markers. It will be appreciated that the amount and type of radiopaque material used may depend, inter alia, on price, desired level of radiopacity, mechanical properties of the radiopaque material, and corrosion properties of the radiopaque material.

In some embodiments, the device **100** is configured to be positioned at a junction of a bifurcation (e.g., a neurovascular bifurcation (e.g., the basilar tip area)) comprising at least one afferent vessel, efferent vessels, and an aneurysm having a fundus and a neck. For example, in some embodiments, the proximal section **102** is suitably dimensioned to fit in an afferent vessel of a bifurcation (e.g., having a diameter between about 2 mm and about 10 mm, having a diameter between about 1 mm and about 15 mm, having a diameter between about 6 mm and about 8 mm, having a diameter less than about 15 mm, having a diameter greater than about 1 mm). In some embodiments, the device **100** is configured to act as a scaffolding to inhibit or prevent herniation or prolapse of objects (e.g., embolization coils, thrombi, etc.) out of a neck of an aneurysm. For another example, in some embodiments, the distal section **106** is dense enough that such objects cannot pass. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is between about 3% and about 25%. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is between about 3% and about 15%. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is at least about 5%. For another example, in some embodiments, the distal section **106** allows insertion of embolic material therethrough (e.g., through apertures or spaces between struts or filaments). In some embodiments, the device **100** is configured to permit perfusion of fluid (e.g., blood) to efferent vessels of a bifurcation. For yet another example, in some embodiments, the intermediate

section is substantially devoid of a covering, mesh, or other material between the struts **105**, thereby allowing fluid to flow substantially unimpeded. Some embodiments of distal sections **106** comprising a plurality of ring assemblies may be easier to deploy than, for example distal sections comprising a flower portion (e.g., the distal section **56** of FIGS. **5**A-**5**D).

FIG. **11** illustrates an example embodiment of a device **100** positioned at a junction of a basilar tip aneurysm **110**. The proximal section **102** is anchored in the afferent or main vessel **112**, the intermediate section **104** allows perfusion to the efferent vessels **114**, and the distal section **116** acts as scaffolding to inhibit herniation of embolic material from the aneurysm **110**. In some embodiments, positioning of the device **100** using the afferent vessel **112** as the delivery path for the device **100** may be accomplished as follows. The distal tip of a delivery catheter (e.g., microcatheter or other catheters that can be tracked through and reach the location of the aneurysm **110**) is placed inside the aneurysm **110** or at the neck of the aneurysm **110**. The device **100** is then is inserted in the proximal end of the catheter or may be positioned in the catheter prior to placement of the distal tip of the delivery catheter. The distal section **106** of the device **100** is then pushed out of the distal end of the catheter (e.g., using a push wire and pulling the catheter back), allowing the distal section **106** to expand (e.g., self-expand) either at least partially inside the aneurysm **110** (e.g., as illustrated in FIG. **11**) or at the neck of the aneurysm **110** to conform to the contour of the neck of the aneurysm **110** and to span the neck of the aneurysm **110** or to reduce the effective size of the neck. The intermediate section **104** of the device **100** is then pushed out of the distal end of the catheter (e.g., using a push wire and pulling the catheter back), allowing the intermediate section **104** to expand (e.g., self-expand) in the junction of the bifurcation. The proximal section **102** of the device **100** is then pushed out of the distal end of the catheter (e.g., using a push wire and pulling the catheter back), allowing the proximal section **102** to expand (e.g., self-expand) in the afferent vessel **112** to maintain the position of the device **100**. The device **100** can be fully retrieved inside the catheter, the position of the catheter can be adjusted, and the device **100** can be redeployed, for example to a more desirable position if the position of any section **102**, **104**, **106** after initial deployment of the device **100** was not as desired after initial deployment. Additionally or alternatively, the device **100** can be fully retrieved inside the catheter and a different catheter or the same catheter with a different device (e.g., a device **100** having different dimensions such as diameter of the proximal portion **102**, length of the intermediate portion **104**, etc.) can be deployed, for example at a more desirable position or with more desirable properties (e.g., better anchoring, better neck coverage, etc.). Once the device **100** is positioned, the device **100** can be detached from the catheter electrolytically, mechanically, or chemically. As described herein, for example with respect to FIGS. **18**A-**20**C, embolic material may be placed in the aneurysm **110** before, after, and/or during positioning of the device **100**. The catheter used to deliver the device **100** may be used to deliver embolic material into the fundus of the aneurysm **110**. The distal section **106** may divert fluid flow from the aneurysm **110**, which may allow the omission of embolic material or an aneurysm filling device. Other delivery methods of the device **100** and other devices described herein are also possible, and it will be appreciated that the basilar tip aneurysm was used merely as an example of a bifurcation.

FIGS. **12**A-**12**J illustrate example embodiments of proximal sections **1221**, **1222**, **1223**, **1224**, **1225**, **1226**, **1227**, **1228**, **1229**, **1230** that may be incorporated into the devices described herein. FIG. **12**A illustrates an example embodiment of a proximal section **1221** having an "open cell" design, identifiable by the reverse free-peaks **124** and the forward free-peaks **125**. Open cell designs generally provide good flexibility and wall apposition, but may be difficult to retrieve, for example due to reverse free-peaks snagging or catching on the catheter during retrieval. FIG. **12**B illustrates an example embodiment of a proximal section **1222** having a "closed cell" design, identifiable by the lack of any peaks due to contact of all cells at intersections **126**. FIG. **12**C illustrates another example embodiment of a proximal section **1223** having a "closed cell" design, identifiable by the lack of reverse free-peaks **127** and forward free-peaks **128**, which are connected by struts **129**. Closed cell designs are generally easy to deliver and to retrieve, but may be stiff and provide poor wall apposition (e.g., being prone to kinking rather than bending).

At least one aspect of the subject technology is the realization that a hybrid of open cell and closed cell designs can advantageously incorporate the advantages of each design and can avoid the potential drawbacks of each design. FIGS. **12**D-**12**H illustrate example embodiments of proximal sections that are "hybrid" or "combination" designs including features of open cell designs and features of closed cell designs. FIG. **12**D illustrates an example embodiment of a proximal section **1224** having a hybrid cell design. The proximal section **1224** comprises forward connected peaks **131**, **133**, forward free-peaks **132**, and reverse connected peaks **134**. The forward peaks **133** are connected to the next unit cell. The proximal section **1224** does not include any reverse free-peaks (**124** of FIG. **12**A). FIG. **12**E illustrates an example embodiment of a proximal section **1225** having a hybrid cell design. The proximal section **1225** comprises forward connected peaks **131**, **133**, forward free-peaks **132**, and reverse connected peaks **134**. The forward peaks **133** are connected to the next unit cell. The proximal section **1225** does not include any reverse free-peaks (**124** of FIG. **12**A). FIG. **12**F illustrates an example embodiment of a proximal section **1226** having a hybrid cell design. The proximal section **1226** comprises forward connected peaks **131**, forward free-peaks **132**, and reverse connected peaks **134**. The proximal section **1226** further comprises valleys **135** connected to the next unit cell. The proximal section **1226** does not include any reverse free-peaks (**124** of FIG. **12**A). FIG. **12**G illustrates an example embodiment of a proximal section **1227** having a hybrid cell design. The proximal section **1227** comprises forward connected peaks **131**, forward free-peaks **132**, and reverse connected peaks **134**. The proximal section **1227** further comprises valleys **135** connected to the next unit cell. The proximal section **1227** does not include any reverse free-peaks (**124** of FIG. **12**A).

FIG. **12**H illustrates an example embodiment of a proximal section **1228** having a hybrid cell design. The proximal section **1228** comprises forward connected peaks **133**, forward free-peaks **132**, and reverse connected peaks **134**. The forward peaks **133** are connected to the next unit cell. Each unit cell comprises forward connected peaks **133** alternating with forward free-peaks **132**. The proximal section **1228** further comprises peaks connected to the next unit cell. The proximal section **1228** does not include any reverse free-peaks (**124** of FIG. **12**A). FIG. **12**I illustrates an example embodiment of a proximal section **1229** having a hybrid cell design. The proximal section **1229** comprises forward connected peaks **133**, forward free-peaks **132**, and reverse connected peaks **134**. The forward peaks **133** are connected to the next unit cell. Each unit cell comprises forward

connected peaks **133** alternating with forward free-peaks **132**. The proximal section **1229** further comprises peaks connected to the next unit cell. The proximal section **1229** does not include any reverse free-peaks (**124** of FIG. **12**A). In contrast to the proximal section **1228** of FIG. **12**H, the proximal section **1229** of FIG. **12**I has fewer diagonal struts (e.g., missing in the area **138**), which may provide better flexibility and/or wall apposition. FIG. **12**J illustrates an example embodiment of a proximal section **1230** having a hybrid cell design. The proximal section **1230** comprises forward connected peaks **133**, forward free-peaks **132**, and reverse connected peaks **134**. The forward peaks **133** are connected to the next unit cell. Each unit cell comprises forward connected peaks **133** alternating with forward free-peaks **132**. The proximal section **1230** further comprises peaks connected to the next unit cell. The proximal section **1230** does not include any reverse free-peaks (**124** of FIG. **12**A). In contrast to the proximal section **1229** of FIG. **12**I, the proximal section **1230** of FIG. **12**J has straight struts **1391**, which may be less prone to twisting during compaction. Combinations of the features of the cell patterns illustrated in FIGS. **12**A-**12**I may be selected based on desired properties of the proximal section.

FIG. **12**B, FIG. **12**D, and FIG. **12**F illustrate proximal sections **1222**, **1224**, **1226**, respectively, having one tapered section **123**, while FIG. **12**A, FIG. **12**C, FIG. **12**E, FIG. **12**G, FIG. **12**H, FIG. **12**I, and FIG. **12**J illustrate proximal portions **1221**, **1223**, **1225**, **1227**, **1228**, **1229**, **1230**, respectively, having two tapered sections **123**. A single tapered section **123** may advantageously have only one detachment zone and be easy to release, while a plurality of tapered sections **123** may comprise a detachment zone proximal to each tapered section **123** and may be more difficult to release. A plurality of tapered sections **123** may have a shorter taper length l_t and a longer effective length l_e (FIG. **9**A, FIG. **9**B, and FIG. **10**C), while a single tapered section **123** may have a longer taper length l_t and a shorter effective length l_e (FIG. **9**A, FIG. **9**B, and FIG. **10**C) and may provide less anchoring in the afferent vessel. A plurality of tapered sections **123** may be more symmetrical and provide more uniform wall apposition. A plurality of tapered sections **123** may have less of a tension effect on the vessel, which may result from a single long tapered area applying force to a single side of the vessel. The effective length l_e of the proximal section may be based on the intended anatomy. Longer lengths may be appropriate for more vessel wall apposition, while shorter lengths may be appropriate for traversing more tortuous anatomy. In some embodiments, the effective length l_e of the proximal section is between about 5 mm and about 40 mm. In some embodiments, the effective length l_e of the proximal section is between about 10 mm and about 30 mm. In some embodiments, the effective length l_e of the proximal section is between about 10 mm and about 20 mm. Other effective lengths l_e are also possible.

FIG. **12**C, FIG. **12**F, and FIG. **12**G illustrate proximal sections **1223**, **1226**, **1227**, respectively, comprising s-shaped struts **129** connecting certain forward peaks and reverse peaks. FIG. **12**D, FIG. **12**E, and FIG. **12**J illustrate proximal portions **1224**, **1225**, **1230**, respectively, comprising straight struts **1391** connecting certain forward peaks and reverse peaks. FIG. **12**H and FIG. **12**I illustrate proximal portions **1228**, **1229** comprising c-shaped struts **1392** connecting certain forward peaks and reverse peaks. Connection struts having an s-shape or c-shape may be more flexible, but may be prone to twisting during compaction, while straight struts may be easier to compress but less flexible, which may be acceptable for hybrid cell designs already having suitable flexibility.

FIG. **12**D and FIG. **12**E illustrate proximal sections **1224**, **1225** having tip-to-tip connections between forward and reverse peaks, which may provide a smaller compaction profile. FIG. **12**F, FIG. **12**G, FIG. **12**H, and FIG. **12**I illustrate proximal sections **1226**, **1227**, **1228**, **1229** having at least partially offset tip-to-tip connections between forward and reverse peaks, which may provide increased flexibility and/or may increase vessel conformance.

FIG. **12**D, FIG. **12**E, FIG. **12**H, FIG. **12**I, and FIG. **12**J illustrate proximal sections **1224**, **1225**, **1228**, **1229**, **1230**, respectively, having tip-to-tip connections between forward and reverse peaks of unit cells, which may provide an easier compaction profile. FIG. **12**F and FIG. **12**G illustrate proximal sections **1226**, **1227** having valley-to-tip connections between forward and reverse peaks of unit cells, which may provide good flexibility.

The patterns described herein can be repeated (e.g., repetition of rows of unit cells), adjusted (e.g., different angles, different lengths, different thicknesses, etc.), and/or combined (e.g., permutations of any of the features disclosed herein) based on the desired properties of the proximal section. In some embodiments, the proximal section may be flow diverting, which may allow the device to be used across sidewall aneurysms, for example as shown in FIG. **4**A. In some embodiments, radiopaque markers are integrated into a portion (e.g., the distal peaks of the forward free-peaks, around the struts, etc.) of the proximal section that the user (e.g., physician) can use to monitor placement of the device.

FIG. **13**A and FIG. **13**B illustrate example embodiments of intermediate sections **1341**, **1342** that may be incorporated into the devices described herein. FIG. **13**A illustrates an example embodiment of an intermediate section **1341** comprising a plurality of straight struts **125**. The number of struts **125** may be selected, for example, based on the expected weight of the embolic coils. For example, as coil weight increases, the number of struts **125** may increase. In some embodiments, the plurality of struts **125** comprises two struts **125**. In some embodiments, the plurality of struts **125** comprises greater than two struts **125**. In some embodiments, the plurality of struts **125** comprises three struts **125** (e.g., as illustrated in FIG. **13**A). In some embodiments, the plurality of struts **125** comprises between about two struts **125** and about twelve struts **125** (e.g., between about three struts **125** and about eight struts **125**, three struts **125**, four struts **125**, five struts **125**, six struts **125**, seven struts **125**, or eight struts **125**). Other numbers of struts **125** are also possible. In some embodiments, the struts **125** may be equally spaced and/or oriented on opposite sides of the device (e.g., two struts 180° apart along the circumference of the device, three struts 120° apart along the circumference of the device, four struts 90° apart along the circumference of the device, etc.).

FIG. **13**B illustrates an example embodiment of an intermediate section **1342** comprising a straight strut **125** and two elongation struts **137** comprising openings. During compaction, the openings of the elongation struts **137** may collapse, thereby increasing the length of the elongation struts **137**. In an example embodiment illustrated in FIG. **13**B, upon compaction the straight strut **125** would maintain length, the middle elongation strut **137** would increase in length somewhat, and the top elongation strut **137** would increase in length the most. The portions of the distal section attached to the strut **125** and elongation struts would be differentiated, which may provide a good compaction profile. For example,

referring again to FIG. **10**C, the rings assemblies in the distal section **106** would be longitudinally spaced when compacted, and also may be less prone to tangling upon expansion.

FIGS. **14**A-**14**F illustrate example embodiments of distal sections that may be incorporated into the devices described herein. FIGS. **14**A-**14**D illustrate example embodiments of distal sections **1461**, **1462**, **1463**, **1464** that may be shaped to form a flower portion, for example as described herein with respect to FIGS. **5**A-**9**B. FIG. **14**A illustrates an example embodiment of a distal section **1461** comprising a plurality of open four-sided cells **141** including an internal strut **142**. The internal struts **142** may provide increased surface area when the distal section **1461** acts as a scaffolding to inhibit herniation of objects out of the neck of an aneurysm and/or may help the distal section **1461** to form the further expanded or substantially planar configuration. FIG. **14**B illustrates another example embodiment of a distal section **1462** comprising a plurality of open four-sided cells **141** including an internal strut **142**. The internal struts **142** may provide increased surface area when the distal section **1462** acts as a scaffolding to inhibit herniation of objects out of the neck of an aneurysm and/or may help the distal section **1462** to form the further expanded or substantially planar configuration. The distal section **1462** includes asymmetric cells **141**, which may expand to a greater diameter and cover aneurysms having wide necks or to reduce the effective neck size. FIG. **14**C illustrates another example embodiment of a distal section **1463** comprising a plurality of open four-sided cells **141** including an internal strut **142**. The internal struts **142** may provide increased surface area when the distal section **1463** acts as a scaffolding to inhibit herniation of objects out of the neck of an aneurysm and/or may help the distal section **1463** to form the further expanded or substantially planar configuration. The distal section **1463** includes disparate asymmetric cells **141**, which may expand to a greater diameter and cover aneurysms having wide necks and/or which may provide a good compaction profile. The distal section **1463** includes cells **141** connected to the intermediate section (illustrated as three struts) at the tips of the cells **141**, which may provide a good compaction profile. FIG. **14**D illustrates another example embodiment of a distal section **1464** comprising a plurality of open six-sided cells **143** including an internal strut **142**. The internal struts **142** may provide increased surface area when the distal section **1464** acts as a scaffolding to inhibit herniation of objects out of the neck of an aneurysm and/or may help the distal section **1464** to form the further expanded or substantially planar configuration. The distal section **1464** includes six-sided cells **143**, which may expand to a greater diameter and cover aneurysms having wide necks and/or which may aid expansion into the further expanded configuration. The distal section **56** of FIG. **5**A is an example embodiment of the distal section **1461** in an expanded or further expanded state. The distal sections **1462**, **1463**, **1464** may have a similar shape (e.g., substantially planar) in the expanded or further expanded state, for example with differences such as, for example, different diameters, peak sharpnesses, etc.

FIG. **14**E illustrates an example embodiment of a distal section **1465** comprising a plurality of ring assemblies. As described with respect to FIGS. **10**A-**10**C, the ring assemblies may each comprise a plurality of rings **107**, **108**, **109** having different flexibility, diameter, etc. In some embodiments, a distal section **1465** comprising a plurality of ring assemblies may be less prone to puncturing vasculature than the peaks of cells of flower portions. In some embodiments, a distal section **1465** comprising a plurality of ring assemblies may be easy to deploy, for example because the deployment force acts on different non-aligned angles. The distal section **106** of FIG. **10**A is an example embodiment of the distal section **1465** in an expanded or further expanded state.

FIG. **14**F illustrates an example embodiment of distal section **1466** comprising a unit cell of a proximal section having a hybrid cell design. The distal section **1466** comprises forward connected peaks **144**, forward free-peaks **145**, and reverse connected peaks **146**, **147**, **148**. The distal section **1466** does not include any reverse free-peaks, which may enhance the ability of the distal section **1466** to be retrieved into a catheter. In some embodiments, the unit cell design of the distal section may be the same as the unit cell design of the proximal section. For example, the distal section **1466** may be combined with the proximal section **1226** of FIG. **12**F or the proximal section **1227** of FIG. **12**G. In some embodiments, the intermediate section may comprise long struts connecting the distal-most unit cell. In some embodiments, the intermediate section may comprise a unit cell.

In some embodiments, the intermediate section and/or the distal section comprises an extension or another generation of the cell pattern of the proximal section that has been reshaped, for example into an approximate semi-sphere, umbrella, or reverse umbrella extending radially outward from the proximal section and then radially inward or outward towards the distal end. FIG. **15** illustrates an example embodiment of an intermediate section and distal section **151** comprising an extension of the cell pattern of the proximal section that has been reshaped into an approximate semi-sphere or umbrella shape. The device **151** may also be in a reverse-umbrella shape. In some embodiments, the section **151** may be easier to manufacture than other sections described herein. In some embodiments, the section **151** may be placed at a bifurcation of an aneurysm as described herein (e.g., at FIG. **7**A and FIG. **7**B). In some embodiments, the section **151** may be placed at least partially within a fundus of an aneurysm (e.g., at FIG. **11** and FIGS. **18**A-**20**E). In certain such embodiments, the proximal section of the device may allow perfusion to efferent vessels.

In the embodiment illustrated in FIG. **15**, the demarcation between the intermediate section and the distal section is not explicit. In some embodiments, the proximal half of the section **151** may be considered the intermediate section. In some embodiments, the portion of the section **151** that does not act as a scaffolding to inhibit herniation of objects out of the neck of an aneurysm may be considered the intermediate section. In some embodiments, the portion of the section **151** that allows perfusion to efferent vessels may be considered the intermediate section. In some embodiments, the intermediate section may at least partially overlap with the distal section. In some embodiments, the entire section after the proximal section may be considered the distal section (e.g., the length of the intermediate section is zero).

Any combination or permutation of the proximal, intermediate, and distal sections described herein, whether in FIGS. **12**A-**15** or elsewhere (e.g., the proximal section **222** of FIG. **22**A, the proximal section **224** of FIG. **22**B, the proximal section **226** of FIG. **22**C, the distal section **236** of FIG. **23**), may be used in an intraluminal device for aneurysm treatment, clot retrieval, or other uses. For example, referring again to FIG. **5**A, the proximal section **52** is the proximal section **1221** of FIG. **12**A, the intermediate section **54** is a plurality of struts **125** of FIG. **13**A (two struts **55**), and the distal section **56** is the distal section **1461** of FIG. **14**A.

For another example, referring again to FIG. **10**C, the proximal section **102** is the proximal section **1225** of FIG. **12**E, the intermediate section **104** is a plurality of struts **125** of FIG. **13**A (three struts **105**), and the distal section **106** is the distal section **1464** of FIG. **14**D. It will be appreciated that a large number of permutations are possible by selecting a proximal section from amongst FIGS. **12**A-**12**G (or equivalents or modifications thereof), selecting an intermediate section from amongst FIG. **13**A and FIG. **13**B (or equivalents or modifications thereof), selecting a distal section from amongst FIGS. **14**A-**14**F (or equivalents or modifications thereof), and/or selecting an intermediate section and distal section from FIG. **15** (or equivalents or modifications thereof). Thus, the devices disclosed herein are not limited to any explicitly illustrated embodiment.

The proximal section, the intermediate section, and the distal section may be integrally formed from the metallic tube or sheet and not cut away from each other. In embodiments in which all sections of the device are integrally fabricated by being cut from the same tube or sheet, the device is of single-piece construction. Single-piece construction may allow for easier manufacturing. In some embodiments, some or all of the proximal section, the intermediate section, and the distal section may be formed separately, and the parts coupled together (e.g., by being welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.). For example, the proximal section and the distal section may be cut from a tube or a sheet and then coupled (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.) by the struts (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.). Certain portions of the proximal section, the intermediate section, and the distal section may be formed separately. For example, a proximal end segments may be cut from a tube or a sheet and then coupled (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.) by connectors. In some embodiments, the distal section may comprise different material than the proximal section. For example, the distal section may comprise platinum, platinum-iridium, or a polymer and the proximal section may comprise Nitinol or CoCr alloy. Other combinations of materials are also possible. Separate or multiple-piece construction may allow for independent selection of materials that are suited for the intended use. In some embodiments, some parts of the distal section (e.g., peaks) are integrated with the proximal section (e.g., being cut from the same tube or sheet) and other parts of the distal section (e.g., struts between peaks) are formed separately from the proximal portion and are attached (e.g., welded, glued, adhered, mechanically crimped, mechanically swaged, braided, physical vapor deposited, chemical vapor deposited, etc.). Combination construction may allow easier fabrication than purely multiple-piece construction and also some material selection advantages.

Referring again to FIG. **9**A and FIG. **9**B, but also applicable to FIGS. **12**A-**15**, the cut may be defined by features such as filament width w, lengths l_1 (e.g., length of a proximal end finger), l_2 (e.g., length of a proximal end segment including fingers), l_3 (e.g., length of a connector coupling proximal section unit cells, length between proximal section unit cells), l_4 (e.g., length of a proximal section unit cell, length of a proximal section unit cell portion), l_5 (e.g., length of intermediate section, length between proximal section and distal section), l_6 (e.g., length between distal section inward-facing peaks), l_7 (e.g., length of the distal section in a partially expanded state), heights h_1 (e.g., height of proximal end segment including fingers), h_2 (e.g., height of a proximal end finger in a first dimension), h_3 (e.g., height between proximal end fingers), h_4 (e.g., height of a proximal end finger in a second dimension), h_5 (e.g., height between free peaks), h_6 (e.g., height of distal section in the expanded state), and angles a_1 (e.g., angle of taper), a_2 (e.g., angle of reverse free peak, angle of reverse connected peaks), a_3 (e.g., angle of at least partially longitudinally projecting filaments), a_4 (e.g., angle of forward free peaks, angle of forward connected peaks), and a_5 (e.g., angle of distal end forward peaks). It will be appreciated that, for different patterns, the configuration and dimensions of certain features will also be different. For example, some cuts may not include certain of the dimensions described herein.

In some embodiments, the width w is between about 0.02 mm and about 0.2 mm. In some embodiments, the width w is between about 0.03 mm and about 0.1 mm. In some embodiments, the width w is about 0.05 mm. Other widths w are also possible. The width w of the filaments may be uniform throughout the device **100**, or may vary depending on location. For example, struts connecting unit cells may be wider than struts within unit cells.

In some embodiments, the tapered length l_t is between about 1.5 mm and about 20 mm. In some embodiments, the tapered length l_t is between about 4 mm and about 15 mm. Other tapered lengths l_t are also possible. In some embodiments, the effective length l_e is between about 5 mm and about 40 mm. In some embodiments, the effective length l_e is between about 10 mm and about 30 mm. In some embodiments, the effective length l_e is between about 10 mm and about 20 mm. Other effective lengths l_e are also possible.

In some embodiments, the length l_2 is between about 0.01 mm and about 2 mm. In some embodiments, the length l_2 is between about 0.05 mm and about 0.75 mm. Other lengths l_2 are also possible. In some embodiments, the length l_3 is between about 0.01 mm and about 3 mm. In some embodiments, the length l_3 is between about 0.1 mm and about 0.5 mm. Other lengths l_3 are also possible. In some embodiments, the length l_4 is between about 1 mm and about 7 mm. In some embodiments, the length l_4 is between about 2 mm and about 5 mm. Other lengths l_4 are also possible. In some embodiments, the length l_5 is between about 0 mm and about 8 mm. In some embodiments, the length l_5 is between about 0 mm and about 10 mm. In some embodiments, the length l_5 is between about 0 mm and about 6 mm. In some embodiments, the length l_5 is between about 6 mm and about 10 mm. In some embodiments, the length l_5 is about 8 mm. In some embodiments, the length l_5 is between about 0 mm and about 5 mm. Other lengths l_5 are also possible. In some embodiments, the length l_6 is between about 0.01 mm and about 3 mm. In some embodiments, the length l_6 is between about 0.05 mm and about 0.5 mm. Other lengths l_6 are also possible. In some embodiments, the length l_7 is between about 0.5 mm and about 10 mm. In some embodiments, the length l_7 is between about 1.5 mm and about 6 mm. Other lengths l_7 are also possible.

In some embodiments, the height h_1 is between about 0.01 mm and about 0.75 mm. In some embodiments, the height h_1 is between about 0.01 mm and about 0.5 mm. Other heights h_1 are also possible. In some embodiments, the height h_4 is between about 0.01 mm and about 0.25 mm. In some embodiments, the height h_4 is between about 0.01 mm and about 0.1 mm. Other heights h_4 are also possible. In some embodiments, the height h_5 is between about 0.25 mm

and about 6 mm. In some embodiments, the height h_5 is between about 0.5 mm and about 3 mm. Other heights h_5 are also possible. In some embodiments, the height h_6 is between about 1.5 mm and about 6 mm in the expanded state. In some embodiments, the height of the distal section is between about 3 mm and about 15 mm in the further expanded state. Other heights h_6 and heights of the distal section in the further expanded state are also possible.

The dimensions described herein, including for example dimensions described with respect to FIG. **9**A, may be uniform throughout the proximal section **102** of the device **100**, or may vary depending on location (e.g., increasing from proximal to distal, decreasing from proximal to distal, combinations thereof, and the like). Dimensions may be selected, for example, to accommodate certain vasculature, for flexibility, for wall conformance, etc.

In some embodiments, other of the dimensions described herein may be uniform throughout the proximal section of the device, or may vary depending on location (e.g., increasing from proximal to distal, decreasing from proximal to distal, combinations thereof, and the like). Dimensions may be selected, for example, to accommodate certain microvasculature, for flexibility, for wall conformance, etc. In some embodiments, a reduced number of the connectors coupling proximal end segments may increase the flexibility of the proximal section of the device.

After cutting the tube or the sheet, the device may be reshaped and the device may be heat treated to impart shape setting to at least the distal section and/or the proximal section **122**. The shape setting process may include several steps comprising, for example, successively shapes using appropriate tooling to stretch and confine the cut tube into a new shape during the heat treatment. At the end of the each heat treatment step, the cut tube or sheet assumes the shape in which it was confined during the heat treatment process. The final shape (e.g., further expanded state) and size may obtained by several such steps. In some embodiments in which a cut sheet is rolled to form a tube, there may be a slit along the length of the device (e.g., the opposite sides of the sheet are not joined), or the edge(s) can be welded or otherwise joined together by other methods to form a complete tubular profile. In certain such embodiments, the sides may be in contact or spaced.

FIG. **16** illustrates an example embodiment of a vascular remodeling device **160** comprising a scaffolding distal section **166** that is woven from a plurality of filaments rather than being cut from a tube or a sheet. The device **160** comprises a proximal section **162**, an intermediate section **164**, and a distal section **166**. The distal section **166** has a further expanded state, and the device **160** acts like an umbrella.

The intermediate section **164** comprises a plurality of struts **165**. The struts **165** may be straight, curved, or otherwise shaped. In some embodiments, the struts **165** have a substantially rectangular or flat cross section (e.g., embodiments, in which the struts **165** comprise ribbons or uncut portions of a metallic tube or sheet). In some embodiments, the struts **165** have a substantially round (e.g., circular, elliptical, ovoid) cross section (e.g., embodiments, in which the struts **165** comprise round filaments). In the example embodiment illustrated in FIG. **16**, the struts **165** comprise a plurality of wires twisted together. The struts **165** couple the proximal section **162** to the distal section **166**. In some embodiments, the plurality of struts **165** comprises two struts **165**. In some embodiments, the plurality of struts **165** comprises greater than two struts **165**. In some embodiments, the plurality of struts **165** comprises between about two struts **165** and about twelve struts **165** (e.g., between about three struts **165** and about eight struts **165**, three struts **165**, four struts **165**, five struts **165**, six struts **165**, seven struts **165**, or eight struts **165**). Other numbers of struts **165** are also possible. In certain embodiments, the struts **165** may be equally spaced and/or oriented on opposite sides of the device **160** (e.g., two struts 180° apart along the circumference of the device **160**, three struts 120° apart along the circumference of the device **160**, four struts 90° apart along the circumference of the device **160**, etc.). When the device **160** is placed at a bifurcation, the intermediate section **164** allows flow to efferent vessels because the struts **165** do not block fluid flow. In some embodiments, the filaments in the intermediate section **164** have a width between about 0.02 mm and about 0.2 mm. In some embodiments, the filaments in the intermediate section **104** have a width between about 0.0035 mm and about 0.005 mm. In some embodiments, the filaments in the intermediate section **104** have a width between about 0.03 mm and about 0.1 mm. In some embodiments, the filaments in the intermediate section **104** have a width of about 0.05 mm. Other widths are also possible. It will be appreciated that in embodiments in which the struts **165** each comprise a plurality of filaments, the width of the struts may be approximately the width of the filaments multiplied by the number of filaments. The intermediate section **164** has a length l_i. In some embodiments, the length l_i is between about 0 mm and about 6 mm. In some embodiments, the length l_i is between about 0 mm and about 8 mm. In some embodiments, the length l_i is between about 0 mm and about 10 mm. In some embodiments, the length l_i is between about 6 mm and about 10 mm. In some embodiments, the length l_i is about 8 mm. Other lengths l_i are also possible.

In some embodiments, the proximal section **162** has a first diameter and the distal section **166** has a second diameter greater than the first diameter (e.g., due to the further expansion or weaving pattern), which may cause the struts **165** to be angled or curved outwards from the longitudinal axis defined by the proximal section **162**. In some embodiments, the proximal section **162** has a round (e.g., circular, elliptical, or ovoid) cross section. In some embodiments, the proximal section **162** includes filaments having a substantially rectangular or flat cross section (e.g., embodiments in which the proximal section **162** comprises ribbons or uncut portions of a metallic tube or sheet). In some embodiments, the proximal section **162** includes filaments having a substantially round (e.g., circular, elliptical, ovoid) cross section (e.g., embodiments, in which the proximal section **162** comprises round filaments). In some embodiments, the proximal section **162** comprises a plurality of woven filaments (e.g., as illustrated in FIG. **16**), which may provide good flexibility. When the device **160** is placed at a bifurcation, the proximal section **162** provides anchoring of the device **160** in the afferent vessel. The proximal section **162** may also facilitate delivery, positioning, and/or retrieval of the device **160**. In some embodiments, the proximal section **162** has a foreshortening rate less than about 20%. In some embodiments in which the struts **165** comprise wire filaments, the proximal section **162** comprises the same wire filaments or the same type of wire filaments as the struts **165**. In some embodiments, the filaments in the proximal section **162** have a width between about 0.02 mm and about 0.2 mm. In some embodiments, the filaments in the proximal section **162** have a width between about 0.0035 mm and about 0.005 mm. In some embodiments, the filaments in the proximal section **162** have a width between about 0.03 mm and about 0.1 mm. In some embodiments, the filaments in the proximal

section **162** have a width of about 0.05 mm. Other widths are also possible. The proximal section **162** has a length l_p. In some embodiments, the length l_p is between about 6.5 mm and about 60 mm. In some embodiments, the length l_p is between about 14 mm and about 45 mm. In some embodiments, the length l_p is between about 5 mm and about 40 mm. In some embodiments, the length l_p is between about 10 mm and about 30 mm. In some embodiments, the length l_p is between about 10 mm and about 20 mm. In some embodiments, the length l_p is between about 10 mm and about 14 mm (e.g., about 12 mm). Other lengths l_p are also possible.

The distal section **166** may have an umbrella shape. The distal section **166** allows for safe and controlled placement of coils, and can be designed to support a certain packing density of coil. Upon deployment, the distal section **166** can be placed at the neck of an aneurysm and can cover the neck enough that aneurysm filling devices can still be positioned inside the aneurysm. In some embodiments, the filaments in the distal section **166** have a width between about 0.02 mm and about 0.2 mm. In some embodiments, the filaments in the distal section **166** have a width between about 0.0015 mm and about 0.002 mm. In some embodiments, the filaments in the distal section **166** have a width between about 0.03 mm and about 0.1 mm. In some embodiments, the filaments in the distal section **166** have a width of about 0.05 mm. Other widths are also possible. In some embodiments, thinner filaments can be more atraumatic than large filaments. The distal section **166** has a diameter d_d. In some embodiments, the diameter d_d is between about 1.5 mm and about 7 mm. In some embodiments, the diameter d_d is between about 1.5 mm and about 6 mm. In some embodiments, the diameter d_d is between about 3 mm and about 15 mm. Other diameters d_d are also possible.

The distal section **166** comprises a plurality of perforations or cells **167** between the filaments. In some embodiments, the cells have a size of about 1 mm×about 1.2 mm. Other cell sizes and relative dimensions (e.g., equal length sides) are also possible. Other cell shapes (e.g., quadrilateral, parallelogram, rhombus, rectangle, square, hexagon, etc.) are also possible. In certain embodiments, a percentage of the distal section **166** covered by the filaments is between about 25% and about 40%. In certain embodiments, a percentage of the distal section **166** covered by the cells **167** is between about 60% and about 75%. Other porosities of the distal section **166** are also possible. In some embodiments, the distal section **166** may comprise a cover (e.g., a polymer cover). In certain embodiments, a porosity between about 60% and about 75% or lower or a cover may help to divert fluid flow away from an aneurysm, as well as providing more scaffolding support for embolic material in the aneurysm. In some embodiments, the distal section **166** comprises one or more of a mesh, a covering, additional filaments, etc. As described herein, for example with respect to FIG. **9**A and FIG. **9**B, heat treatment may be used to shape set the distal section **166** in the umbrella shape and the distal section **166** can have a further expanded shape.

In some embodiments, the device **160** comprises a self-expanding (e.g., CoCr alloy, such as polyglycolic acid and polylactic acid, etc.) and/or a shape-memory material (e.g., comprising Nitinol, shape memory polymers, etc.), thereby causing the device **160** to be self-expanding under certain conditions (e.g., not restrained by a catheter, temperature modified, etc.). In some embodiments, the proximal section **162**, the intermediate section **164**, and/or the distal section **166** may comprise different materials (e.g., in addition to having different thicknesses as described herein). The device **160** can assume a low profile compressed state (e.g., confined within a catheter) for delivery. Upon deployment from the catheter, the device **160** expands (e.g., self-expands) from the compressed state to an expanded state. The distal section **166** expands (e.g., self-expands) to a further expanded state.

In some embodiments, the device **160** comprises a radiopaque material such as platinum, platinum-iridium, and/or tantalum (e.g., being at least partially formed from the radiopaque material (e.g., having a radiopaque layer, consisting of a radiopaque material), including radiopaque markers). For example, the struts **165** may comprise radiopaque markers. For another example, certain segments of the distal section **166** may comprise radiopaque markers. For yet another example, the struts **165** and certain segments of the distal section **166** may comprise radiopaque markers. For still another example, certain segments of the proximal section **164** may comprise radiopaque markers. It will be appreciated that the amount and type of radiopaque material used may depend, inter alia, on price, desired level of radiopacity, mechanical properties of the radiopaque material, and corrosion properties of the radiopaque material.

In some embodiments, the device **160** is configured to be positioned at a junction of a bifurcation (e.g., a neurovascular bifurcation (e.g., the basilar tip area)) comprising at least one afferent vessel, efferent vessels, and an aneurysm having a fundus and a neck. For example, in some embodiments, the proximal section **162** is suitably dimensioned to fit in an afferent vessel of a bifurcation (e.g., having a diameter between about 3 mm and about 15 mm, having a diameter between about 1.5 mm and about 8 mm, having a diameter between about 1.5 mm and about 7 mm, having a diameter between about 1.5 mm and about 6 mm, having a diameter less than about 15 mm, having a diameter greater than about 1 mm). In some embodiments, the device **160** is configured to act as a scaffolding to inhibit or prevent herniation or prolapse of objects (e.g., embolization coils, thrombi, etc.) out of a neck of an aneurysm. For another example, in some embodiments, the distal section **166** is dense enough that such objects cannot pass. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is between about 3% and about 25%. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is between about 3% and about 15%. In some embodiments, a relative amount of the distal section **56** or a portion thereof occupied by the filaments of the distal section **56** is at least about 5%. For another example, in some embodiments, the distal section **166** allows insertion of embolic material therethrough (e.g., through the cells **167**). In some embodiments, the device **160** is configured to permit perfusion of fluid (e.g., blood) to efferent vessels of a bifurcation. For yet another example, in some embodiments, the intermediate section is substantially devoid of a covering, mesh, or other material between the struts **165**, thereby allowing fluid to flow substantially unimpeded.

FIG. **17** illustrates an example embodiment of a vascular remodeling device **170** comprising a proximal section **172**, an intermediate section **174** comprising a plurality of struts **175**, and a distal section **176**. As described herein, for example with respect to FIG. **16**, the distal section **176** has a further expanded state, and the device **170** acts like an umbrella in that upon expansion the edges of the distal section **176** move longitudinally relative to the center of the distal section **176** and the edges of the distal section **176** move radially outward upon the longitudinal movement. In

contrast to the device **160**, the device **170** comprises a proximal section **172** and/or a distal section **176** comprising cells **177** cut from a sheet or a tube and then coupled to the intermediate section **174**. The proximal section **172** has an effective length l_p (e.g., a tapered portion is not shown, but may be proximal to the illustrated proximal section **172**). In some embodiments, the length l_p is between about 6.5 mm and about 60 mm. In some embodiments, the length l_p is between about 14 mm and about 45 mm. In some embodiments, the length l_p is between about 5 mm and about 40 mm. In some embodiments, the length l_p is between about 10 mm and about 30 mm. In some embodiments, the length l_p is between about 10 mm and about 20 mm. In some embodiments, the length l_p is between about 10 mm and about 14 mm (e.g., about 12 mm). Other lengths l_p are also possible. The intermediate section **174** has a length l_i. In some embodiments, the length $\mathbf{1}_i$ is between about 0 mm and about 5 mm. In some embodiments, the length $\mathbf{1}_i$ is between about 0 mm and about 6 mm. In some embodiments, the length l_i is between about 0 mm and about 8 mm. In some embodiments, the length l_i is between about 0 mm and about 10 mm. In some embodiments, the length l_i is between about 6 mm and about 10 mm (e.g., about 8 mm). Other lengths l_i are also possible.

The distal section **176** has an expanded or further expanded diameter d_d that is greater than the expanded diameter d_p of the proximal section **172**. In some embodiments, the diameter d_d is between about 1.5 mm and about 6 mm. Other diameters d_d are also possible. In some embodiments, the diameter d_p is between about 3 mm and about 15 mm. Other diameters d_p are also possible.

FIGS. **18**A-**18**E illustrate an example embodiment of a method for treating an aneurysm **20** using a vascular remodeling device (e.g., the devices **50**, **100**, **160**, **170** described herein) at a confluence of afferent and efferent vessels or "junction" at a bifurcation having an aneurysm **20**. In some embodiments, the vessels are neurovascular or cranial. FIG. **18**A shows a catheter **180** (e.g., microcatheter) positioned in the afferent vessel and projecting into the bifurcation. FIG. **18**B shows the distal section **186** being deployed at least partially within the fundus of the aneurysm **20** (e.g., by being pushed out with a plunger, by retracting the catheter while the device remains stationary, etc.) and expanding as described herein. In some embodiments, the distal section **186** abuts the neck of the aneurysm **20** but is not inserted in the aneurysm **20**. In some embodiments, the device comprises a self-expanding and/or a shape-memory material that automatically expands (e.g., self-expands) towards an uncompressed state or does so upon the application of warm fluid (e.g., saline). As shown in FIG. **18**C and FIG. **18**D, a second catheter **181** is used to insert embolic coils **62** in the aneurysm **20** while the proximal section **182** of the device remains in the catheter **180**. It will be appreciated that the embolization coils **62** may be a single embolization coil or other embolic material (e.g., embolic fluid such as Onyx®, available from ev3). The device acts as a scaffolding to inhibit or prevent herniation or prolapse of objects such as the embolization coils **62** and/or thrombi out of the aneurysm **20**. The second catheter **181** is then removed, and the catheter **180** is removed to deploy the proximal section **182** in the afferent vessel. The device also allows perfusion of fluid (e.g., blood) from the afferent vessel(s) to the efferent vessel(s).

FIGS. **19**A-**19**E illustrate another example embodiment of a method for treating an aneurysm **20** using a vascular remodeling device (e.g., the devices **50**, **100**, **160**, **170** described herein) at a confluence of afferent and efferent vessels or "junction" at a bifurcation having an aneurysm **20**. In some embodiments, the vessels are neurovascular or cranial. FIG. **19**A shows a catheter **180** (e.g., microcatheter) positioned in the afferent vessel and projecting into the bifurcation. FIG. **19**B shows the distal section **186** being deployed at least partially within the fundus of the aneurysm **20** (e.g., by being pushed out with a plunger, by retracting the catheter while the device remains stationary, etc.) and expanding as described herein. In some embodiments, the distal section **186** abuts the neck of the aneurysm **20** but is not inserted in the aneurysm **20**. In some embodiments, the device comprises a self-expanding and/or a shape-memory material that automatically expands (e.g., self-expands) towards an uncompressed state or does so upon the application of warm fluid (e.g., saline). FIG. **19**C shows the entire device including the proximal section **182** being released from the catheter **180** and the catheter **180** being removed prior to inserting a second catheter **181**. The proximal section **182** anchors the device in the afferent vessel. As shown in FIG. **19**C and FIG. **18**D, a second catheter **181** is used to insert embolic coils **62** in the aneurysm **20**. It will be appreciated that the embolization coils **62** may be a single embolization coil or other embolic material (e.g., embolic fluid such as Onyx®, available from ev3). The device acts as a scaffolding to inhibit or prevent herniation or prolapse of objects such as the embolization coils **62** and/or thrombi out of the aneurysm **20**. The second catheter **181** is then removed. The device also allows perfusion of fluid (e.g., blood) from the afferent vessel(s) to the efferent vessel(s).

FIGS. **20**A-**20**C illustrate yet another example embodiment of a method for treating an aneurysm **20** using a vascular remodeling device (e.g., the devices **50**, **100**, **160**, **170** described herein) at a confluence of afferent and efferent vessels or "junction" at a bifurcation having an aneurysm **20**. In some embodiments, the vessels are neurovascular or cranial. FIG. **20**A shows a catheter **180** (e.g., microcatheter) positioned in the afferent vessel and projecting into the bifurcation. FIG. **20**B shows the distal section **186** being deployed at least partially within the fundus of the aneurysm **20** (e.g., by being pushed out with a plunger, by retracting the catheter while the device remains stationary, etc.) and expanding as described herein. In some embodiments, the distal section **186** abuts the neck of the aneurysm **20** but is not inserted in the aneurysm **20**. In some embodiments, the device comprises a self-expanding and/or a shape-memory material that automatically expands (e.g., self-expands) towards an uncompressed state or does so upon the application of warm fluid (e.g., saline). FIG. **20**C shows the entire device including the proximal section **182** being released from the catheter **180** and the catheter **180** being removed prior. The proximal section **182** anchors the device in the afferent vessel. In contrast to the methods described with respect to FIGS. **18**A-**19**E, a second catheter is not used to insert embolic material in the aneurysm **20**. Rather, the embodiment of the device used in the method of FIGS. **20**A-**20**C either comprises a porosity or covering that can divert fluid flow. The device also allows perfusion of fluid (e.g., blood) from the afferent vessel(s) to the efferent vessel(s).

Certain devices described herein may be advantageously used to treat aneurysms having a neck ratio (a ratio of fundus width to neck width) greater than about 2 to 1 and/or a neck width greater than about 4 mm. In treatment of such aneurysms, embolization coils may be prone to herniating into parent vessels because the size and/or shape of the aneurysm is not conducive to maintaining the coils in their inserted locus. In some embodiments, embolization coils are inserted

in the fundus of the aneurysm after positioning a generally spherical device so that the embolization coils do not have an opportunity to herniate. It will be appreciated that certain devices described herein may also be used to treat aneurysms having a neck ratio less than about 2 to 1 and/or a neck width less than about 4 mm. In some embodiments, embolization coils are inserted in the fundus of the aneurysm before positioning a generally spherical device.

In some embodiments in which embolic material was previously inserted in an aneurysm but has herniated, certain devices described herein may be used as a "rescue device" to push the herniated material back into the aneurysm and to act as a scaffolding to inhibit or prevent further herniation or prolapse of the embolic material. In certain such embodiments, deployment of such devices may advantageously avoid traversal of the junction comprising the herniated material by wires or a catheter (e.g., there is no need to traverse wires or a catheter past the junction into an efferent vessel for positioning of the device as is generally needed to position tubular devices such as the devices **42**, **44** illustrated in FIG. **4**B and FIG. **4**C), which may cause the herniated material to become tangled and/or dislodged and which may cause rupture of the aneurysm.

Certain devices described herein may also be useful to treat or inhibit ischemic stroke and other diseases by being used to retrieve thrombi or blood clots. U.S. patent application Ser. No. 12/918,795, filed on Feb. 20, 2009 and published as U.S. Patent Pub. No. 2011/0060212 on Mar. 10, 2011, describes methods of using devices having porous proximal sections for clot retrieval, and is hereby incorporated by reference in its entirety. The devices described herein comprise a distal section configured to act as a scaffolding to inhibit herniation of objects out of an aneurysm, and the distal section may also be used for distal protection during retrieval of soft or firm clots or clot fragments while allowing continued blood flow through the vessel due to the distal section not preventing fluid flow.

FIG. **21**A illustrates an example embodiment of a method of capturing a clot **210** using a device **50** comprising a distal section **56** and a proximal section **52** within a catheter **180**. The distal section **56** comprises a flower portion as described herein, for example with respect to FIGS. **5**A-**9**B. In some embodiments, the distal end of the catheter **180** at least partially containing the device **50** in a compressed state is placed distal to the clot **210** as determined by the direction of blood flow indicated by the arrow **214**. The catheter **180** is then retracted relative to the device **50**. Upon exposure from the catheter **180**, the device **50** expands (e.g., self-expands) from the compressed state to an expanded state. As described herein, the distal section **56** may expand (e.g., self-expand) to a further expanded state. In the further expanded state, the distal section **56** has a larger diameter than the proximal section **52**. The proximal section **52** expands alongside the clot **210** and the distal section **56** expands distal to the clot **210**. The flexibility of the proximal section **52** may be low to enhance resistance to clot **210** force (e.g., to cause the clot **210** to squish around the filaments). The clot **210** at least partially squeezes between the cells of the proximal section **52** and becomes lodged therein. In some embodiments, the distal section **56** expands to approximately the diameter of the vessel containing the clot. In this manner, the scaffolding of the distal section **56** can catch any clots or clot fragments that may be too small to be caught by the proximal section **52**. The diameter and flexibility of the distal section **56** can provide good wall apposition to leave little (e.g., no) space for clot small clots or clot fragments (e.g., the clot fragment **212**) to flow past while still allowing blood to flow through the vessel. Once the clot **210** and clot fragments are caught in the device **50**, the device **50** is retrieved back into the catheter **180**, for example by distally advancing the catheter **180** over the device **50** or pulling the device **50** into the catheter **180**. In some embodiments, catheter **180** may be a guide catheter configured to receive the device **50** and clot **210** and/or clot fragments. During retrieval, the tapered portions **53** cause the device **50** to be radially compressed back into the catheter **180** along with the clot **210** and clot fragment **212**. If pieces of the clot **210** break off during retrieval (e.g., the clot fragment **212**), they can be caught in the distal section **56**, which is the last portion of the device to be compressed into the catheter **180**. The catheter **180** may then be removed from the body. The distal section **56** thus provides integrated embolic protection during the clot **210** retrieval procedure (e.g., nor requiring a separate filter or other embolic protection device). In some embodiments in which the device **50** is formed from a sheet, the edges of the sheet are not coupled in at least the proximal section **52** to leave a slot, and the edges may overlap to form a coiled configuration when viewed from the distal end to enhance interaction with the clot **210** (e.g., by springing open upon release from the catheter **180** and/or by acting as jaws that clamp down on the clot **210** during retrieval of the device **50**). In some embodiments in which the device **50** is formed from a tube, the proximal section **52** comprises a longitudinal slot to form two edges, and the edges may overlap to form a coiled configuration when viewed from the distal end to enhance interaction with the clot **210** (e.g., by springing open upon release from the catheter **180** and/or by acting as jaws that clamp down on the clot **210** during retrieval of the device **50**). In some embodiments in which the clot **210** is proximate to a bifurcation, the diameter of the distal section **56** may substantially span (e.g., span) the junction of a bifurcation, allowing perfusion to efferent vessels.

FIG. **21**B illustrates an example embodiment of a method of capturing a clot **210** using a device **100** comprising a distal section **106** and a proximal section **102** within a catheter **180**. The distal section **106** comprises a plurality of rings as described herein, for example with respect to FIGS. **10**A-**11**. In some embodiments, the distal end of the catheter **180** at least partially containing the device **100** in a compressed state is placed distal to the clot **210** as determined by the direction of blood flow indicated by the arrow **214**. The catheter **180** is then retracted relative to the device **100**. Upon exposure from the catheter **180**, the device **100** expands (e.g., self-expands) from the compressed state to an expanded state. As described herein, the distal section **106** may expand (e.g., self-expand) to a further expanded state. In the further expanded state, the distal section **106** has a larger diameter than the proximal section **102**. The proximal section **102** expands alongside the clot **210** and the distal section **106** expands distal to the clot **210**. The flexibility of the proximal section **102** may be low to enhance resistance to clot **210** force (e.g., to cause the clot **210** to squish around the filaments). The clot **210** at least partially squeezes between the cells of the proximal section **102** and becomes lodged therein. In some embodiments, the distal section **106** expands to approximately the diameter of the vessel containing the clot. In this manner, the scaffolding of the distal section **106** can catch any clots or clot fragments that may be too small to be caught by the proximal section **102**. The diameter and flexibility of the distal section **106** can provide good wall apposition to leave little (e.g., no) space for clot small clots or clot fragments (e.g., the clot fragment **212**) to flow past while still allowing blood to flow through the

vessel. Once the clot **210** and clot fragments are caught in the device **100**, the device **100** is retrieved back into the catheter **180**, for example by distally advancing the catheter **180** over the device **100** or pulling the device **100** into the catheter **180**. During retrieval, the tapered portions **103** cause the device **100** to be radially compressed back into the catheter **180** along with the clot **210** and clot fragment **212**. If pieces of the clot **210** break off during retrieval (e.g., the clot fragment **212**), they can be caught in the distal section **106**, which is the last portion of the device to be compressed into the catheter **180**. The catheter **180** may then be removed from the body. The distal section **106** thus provides integrated embolic protection during the clot **210** retrieval procedure (e.g., nor requiring a separate filter or other embolic protection device). In some embodiments in which the device **100** is formed from a sheet, the edges of the sheet are not coupled in at least the proximal section **102** to leave a slot, and the edges may overlap to form a coiled configuration when viewed from the distal end to enhance interaction with the clot **210** (e.g., by springing open upon release from the catheter **180** and/or by acting as jaws that clamp down on the clot **210** during retrieval of the device **100**). In some embodiments in which the device **100** is formed from a tube, the proximal section **102** comprises a longitudinal slot to form two edges, and the edges may overlap to form a coiled configuration when viewed from the distal end to enhance interaction with the clot **210** (e.g., by springing open upon release from the catheter **180** and/or by acting as jaws that clamp down on the clot **210** during retrieval of the device **100**). In some embodiments in which the clot **210** is proximate to a bifurcation, the diameter of the distal section **106** may substantially span (e.g., span) the junction of a bifurcation, allowing perfusion to efferent vessels.

FIG. **21**C illustrates an example embodiment of a method of capturing a clot **210** using a device **1510** comprising a distal section **151** and a proximal section **1512** within a catheter **180**. The distal section **151** comprises a semi-sphere or umbrella shape as described herein, for example with respect to FIG. **15**. In some embodiments, the distal end of the catheter **180** at least partially containing the device **1510** in a compressed state is placed distal to the clot **210** as determined by the direction of blood flow indicated by the arrow **214**. The catheter **180** is then retracted relative to the device **1510**. Upon exposure from the catheter **180**, the device **1510** expands (e.g., self-expands) from the compressed state to an expanded state. As described herein, the distal section **151** may expand (e.g., self-expand) to a further expanded state. In the further expanded state, the distal section **151** has a larger diameter than the proximal section **1512**. The proximal section **1512** expands alongside the clot **210** and the distal section **151** expands distal to the clot **210**. The flexibility of the proximal section **1512** may be low to enhance resistance to clot **210** force (e.g., to cause the clot **210** to squish around the filaments). The clot **210** at least partially squeezes between the cells of the proximal section **1512** and becomes lodged therein. In some embodiments, the distal section **151** expands to approximately the diameter of the vessel containing the clot. In this manner, the scaffolding of the distal section **151** can catch any clots or clot fragments that may be too small to be caught by the proximal section **1512**. The diameter and flexibility of the distal section **151** can provide good wall apposition to leave little (e.g., no) space for clot small clots or clot fragments (e.g., the clot fragment **212**) to flow past while still allowing blood to flow through the vessel. Once the clot **210** and clot fragments are caught in the device **1510**, the device **1510** is retrieved back into the catheter **180**, for example by distally advancing the catheter **180** over the device **1510** or pulling the device **1510** into the catheter **180**. During retrieval, the tapered portions **1503** cause the device **1510** to be radially compressed back into the catheter **180** along with the clot **210** and clot fragment **212**. If pieces of the clot **210** break off during retrieval (e.g., the clot fragment **212**), they can be caught in the distal section **151**, which is the last portion of the device to be compressed into the catheter **180**. The catheter **180** may then be removed from the body. The distal section **151** thus provides integrated embolic protection during the clot **210** retrieval procedure (e.g., nor requiring a separate filter or other embolic protection device). In some embodiments in which the device **1510** is formed from a sheet, the edges of the sheet are not coupled in at least the proximal section **1512** to leave a slot, and the edges may overlap to form a coiled configuration when viewed from the distal end to enhance interaction with the clot **210** (e.g., by springing open upon release from the catheter **180** and/or by acting as jaws that clamp down on the clot **210** during retrieval of the device **1510**). In some embodiments in which the device **1510** is formed from a tube, the proximal section **1512** comprises a longitudinal slot to form two edges, and the edges may overlap to form a coiled configuration when viewed from the distal end to enhance interaction with the clot **210** (e.g., by springing open upon release from the catheter **180** and/or by acting as jaws that clamp down on the clot **210** during retrieval of the device **1510**). In some embodiments in which the clot **210** is proximate to a bifurcation, the diameter of the distal section **151** may substantially span (e.g., span) the junction of a bifurcation, allowing perfusion to efferent vessels.

FIGS. **22**A-**22**C illustrate example embodiments of proximal sections **222**, **224**, **226**, comprising additional filaments or features that can enhance clot retrieval. FIG. **22**A illustrates an example embodiment of a proximal section **222** of a device comprising a plurality of substantially longitudinally straight and radially curved filaments **223** extending between the proximal end of the proximal section **222** and the distal end of the proximal section **222**. FIG. **22**B illustrates an example embodiment of a proximal section **224** of a device comprising a plurality of spiraled filaments **225** extending between the proximal end of the proximal section **224** and the distal end of the proximal section **224** and/or extending radially outward from the proximal section **224**. FIG. **22**C illustrates an example embodiment of a proximal section **226** of a device comprising a plurality of substantially longitudinally straight and radially curved filaments **223** extending between the proximal end of the proximal section **226** and the distal end of the proximal section **226** and a plurality of spiraled filaments **225** extending between the proximal end of the proximal section **226** and the distal end of the proximal section **226** and/or extending radially outward from the proximal section **226**. FIG. **23** illustrates an example embodiment of a device **230** comprising a distal section **236** comprising a plurality of branches **237**. The branches **237** may enhance the capture of stray clots or clot fragments. The branches **237** may also be configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm. As described herein, any combination or permutation of the proximal, intermediate, and distal sections described herein may be used in an intraluminal device for aneurysm treatment, clot retrieval, or other uses.

Although the subject technology has been disclosed in the context of certain embodiments and examples, it will be understood by those skilled in the art that the subject technology extends beyond the specifically disclosed

embodiments to other alternative embodiments and/or uses of the subject technology and obvious modifications and equivalents thereof. In addition, while several variations of the embodiments of the subject technology have been shown and described in detail, other modifications, which are within the scope of the subject technology, will be readily apparent to those of skill in the art based upon this disclosure. It is also contemplated that various combinations or sub-combinations of the specific features and aspects of the embodiments may be made and still fall within the scope of the subject technology. It should be understood that various features and aspects of the disclosed embodiments can be combined with, or substituted for, one another in order to form varying modes of the embodiments of the disclosed subject technology. Thus, it is intended that the scope of the subject technology disclosed herein should not be limited by the particular embodiments described above.

What is claimed is:

1. An intraluminal device comprising:

a proximal section configured to anchor in an afferent vessel;

an intermediate section comprising a plurality of struts configured to allow perfusion to efferent vessels;

a distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm;

wherein each of the plurality of struts is coupled to the distal section at a coupling at a region between a proximal end of the distal section and a distal end of the distal section;

wherein the distal section is biased to transition from a compressed state to a radially expanded state when released from a catheter, wherein, while transitioning from the compressed state to the radially expanded state, the distal end moves radially outwardly and proximally relative to the proximal section, and the proximal end of the distal section moves radially inwardly and distally relative to the proximal section.

2. The intraluminal device of claim **1**, wherein, while in the expanded state, the proximal end and the distal end are substantially axially aligned with the coupling.

3. The intraluminal device of claim **1**, wherein, while in the expanded state, the distal end defines an outermost cross-sectional dimension that is greater than an outermost cross-sectional dimension of the proximal section.

4. The intraluminal device of claim **1**, wherein, while in the expanded state, the proximal end defines an innermost cross-sectional dimension that is less than an innermost cross-sectional dimension of the proximal section.

5. The intraluminal device of claim **1**, wherein, while in the expanded state, the proximal end defines a first lumen sized smaller than a second lumen defined by the proximal section.

6. The intraluminal device of claim **1**, wherein the proximal section is detachably coupled to a delivery member.

7. An intraluminal device comprising:

a proximal section configured to anchor in an afferent vessel;

an intermediate section comprising a plurality of struts configured to allow perfusion to efferent vessels;

a distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm;

wherein each of the plurality of struts is coupled to the distal section at a coupling at a region between a proximal end of the distal section and a distal end of the distal section;

wherein each of the proximal end and the distal end is biased to pivot about the coupling, such that the distal section at least partially everts when released from a catheter,

wherein, when released from the catheter, the proximal end and the distal end are configured to become substantially axially aligned with the coupling.

8. The intraluminal device of claim **7**, wherein, when released from the catheter, the distal end is configured to define an outermost cross-sectional dimension that is greater than an outermost cross-sectional dimension of the proximal section.

9. The intraluminal device of claim **7**, wherein, when released from the catheter, the proximal end is configured to define an innermost cross-sectional dimension that is less than an innermost cross-sectional dimension of the proximal section.

10. The intraluminal device of claim **7**, wherein, when released from the catheter, the proximal end is configured to define a first lumen sized smaller than a second lumen defined by the proximal section.

11. The intraluminal device of claim **7**, wherein the proximal section is detachably coupled to a delivery member.

12. An intraluminal device comprising:

a proximal section configured to anchor in an afferent vessel;

an intermediate section comprising a plurality of struts configured to allow perfusion to efferent vessels;

a distal section configured to act as a scaffolding to inhibit herniation of objects out of a neck of a bifurcation aneurysm;

wherein each of the plurality of struts is coupled to the distal section at a coupling at a region between a proximal end of the distal section and a distal end of the distal section;

wherein the distal section is biased to transition from a compressed state forming a substantially cylindrical shape to a radially expanded state forming a substantially planar shape when released from a catheter,

wherein, while in the expanded state, the proximal end and the distal end are substantially axially aligned with the coupling.

13. The intraluminal device of claim **12**, wherein, while in the expanded state, the distal end defines an outermost cross-sectional dimension that is greater than an outermost cross-sectional dimension of the proximal section.

14. The intraluminal device of claim **12**, wherein, while in the expanded state, the proximal end defines an innermost cross-sectional dimension that is less than an innermost cross-sectional dimension of the proximal section.

15. The intraluminal device of claim **12**, wherein, while in the expanded state, the proximal end defines a first lumen sized smaller than a second lumen defined by the proximal section.

16. The intraluminal device of claim **12**, wherein the proximal section is detachably coupled to a delivery member.

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